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»STUDY ON THE ECONOMIC IMPACT OF BLOCKCHAIN ON THE DANISH INDUSTRY AND LABOR MARKET«

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Preface

Blockchain technology has received significant attention in recent years. The discussions have been around its functionalities, large potentials, as well as potentially new groundbreaking business models and on how the technology should be implemented to the benefit of Danish industry.

Even though blockchain has been much debated, specific experiences from Danish companies are still limited, and until now there has been no systematic overview regarding the development of blockchain in Denmark. This has changed now with the report at hand.

The report is a joined achievement of the European Blockchain Center at the IT University of Copenhagen, Fraunhofer Institute for Industrial Engineering, Confederation of Danish Industry, Statistics Denmark, and the Danish Industry Foundation and focuses on the application of blockchain technologies in different industry sectors in Denmark. The report provides a general introduction into blockchain, an analysis of clusters, a review of the comprehensive empirical study, a comparison with selected countries, scenario analyses, and finally recommendations in the conclusion.

In other words, the report presents a mapping of Danish clusters from a blockchain perspective and a status overview on the application and future plans when it comes to blockchain in six different Danish industry sectors with a focus upon opportunities as well as barriers. Further relevant considerations from abroad are presented as well as an analysis of significant scenarios.

The report provides the needed empirical background for decision makers in industry as well as politics regarding the status quo and future of blockchain and distributed ledger technologies in Denmark. The report provides first evidence that more effort is needed and a coordinated plan comprising private and public institutions to further stimulate the growth of the emerging blockchain industry as innovation driver for other industries. Further it seems advantageous to look at other countries whom have obtained valuable experiences already, as it is crucial to ensure the availability of the right competences for Danish businesses and industries – to the extent it is relevant – to obtain the knowledge and labor needed to develop a competitive Danish industry around blockchain.

Precisely such challenges have been addressed by The Danish Industry Foundation in a theme-call on competitive power from blockchain. The call is based upon the general interest of the Fund in new technologies, and has resulted in a number of projects, each of which will create new knowledge and new experiences through the use of blockchain technologies in Danish corporate life. With the mapping at hand a baseline has been defined. Now it is time for creating positive impact and change.

Enjoy reading!

Thomas Hofman-Bang

CEO

The Danish Industry Foundation

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Executive Summary

OVERVIEW

Blockchain is regarded as equally important or even more important than the Internet. Blockchain enforces business logics among and across several stakeholders within a supply chain, thereby minimizing transaction costs, providing a transparent economy where transparency is needed. Thus, having a more precise understanding of the economic impact of the emerging blockchain industry on a macroeconomic level for Denmark is of vital importance for decision makers. The study at hand for Denmark is the first worldwide covering several industries on a national level. The study was made on behalf of Danish The Danish Industry Foundation by the European Blockchain Center at IT-University Copenhagen in close cooperation with Fraunhofer IAE and Danmarks Statistik.

The purpose of the study is to provide solid evidence for decision makers in industry and politics about the future positioning and strategy for blockchain development and assimilation in Denmark. We specifically focus on how Danish companies can build and steer successful blockchain innovations while driving societal welfare at the same time. The empirical study follows a quantitative research methodology able to capture current interrelationships and numerical characteristics in the Danish economy. The study also discloses causal relations on why companies assimilate blockchain technologies, as well as drivers and barriers for doing so. With more than 1,300 responding Danish companies, or 44 percent response rate, the study covers over 20 percent of all companies in the researched industries in Denmark.

WHY A STUDY ON BLOCKCHAIN?

Blockchain has attracted great interest not only from the IT industry, but also from other industries and governments around the world. Originally associated with Bitcoin, blockchain is now spreading as a generic infrastructure technology offering extreme security, safety as well as new services to meet severely heightened requirements for privacy management of personal data.

Increasingly, large companies are forming alliances and consortiums around blockchain technologies investing significantly in its research and development. As an example, more than 145 companies including IBM, Microsoft, Cisco, Intel, JP Morgan and Toyota form the Hyperledger consortium.

The commonly used trusted third-party model to deal with the lack of trust is found increasingly to be inefficient, generating transaction costs that pile up to billions of U.S. dollars per year while excluding a significant number of the world's population and companies from participation. The trusted third-party model centralizes information and concentrates high power in third parties like financial institutions making them also a

systemic risk as they are under constant attacks from hackers. The processing of information by third parties introduces delays in transactions and may be limited geographically, thus creating friction in transaction processes.

As blockchain technologies are still at an early stage of development we only have seen the beginning so far, as the assimilation still faces technical, societal and legal challenges. A key driver for the use of blockchain however are the potential significant savings, as well as potential new services, made possible by technology-mediated trust.

A blockchain is a distributed tamper-resistant digital ledger, a log of all individual transactions conducted within a given system. These lists are grouped into blocks that are chained together so that any manipulation of data afterwards is made extremely difficult. Blockchain uses cryptographic algorithms to verify the creation and transfer of digitally represented assets or information over a peer to peer network. An innovative combination of distributed consensus protocols, cryptography, and in-built economic incentives is used to govern the network. A transaction in a blockchain network is stored in the ledger only if a set of peers validate the transaction through a consensus algorithm.

Blockchain technology decentralizes information storage, reduces or eliminates the need of third parties and provides trust through technology and algorithms often publicly verifiable. In a nutshell, blockchains are decentralized, immutable, secure, consensual, and programmable to enforce business logics.

BLOCKCHAIN AND ITS IMPACT ON THE ECONOMY

Blockchain technologies have the potential to change existing business models and thus have a transformative impact on industries, governments, and societies. For example, the World Economic Forum expects at least 10 percent of the global GDP being stored on blockchain platforms by 2025.

Through blockchain technologies, value creators such as artists, composers, and designers could transfer value to their clients or consumers directly. Blockchain technologies make it possible to track and trace intellectual transfers of property thereby protecting equally producers and consumers of products and services. Blockchain allows the inclusion of self-regulating and self-controlling elements that give users the opportunity to manage and govern the platforms themselves. Through the use of blockchain-based platforms, users cannot only use the services, but also obtain additional benefits from participating in the management and control of the network. Additionally, blockchain can also include micro-payment mechanisms previously not economically practical, increasing the level of security and privacy for users making the platforms more efficient and independent.

Obviously, there are also challenges that still exist when it comes to blockchain technologies. For example, in decentralized applications, nodes may be located in different countries and thus different jurisdictional spheres, which makes it challenging to determine which compliance rules, policies or laws have to be applied.

Privacy and confidentiality are central issues in a blockchain solution and not being able to deal with them may slow down the deployment of applications. Many blockchain applications unquestionably require linking transactions to known identities raising the requirements for data privacy. As blockchain applications introduce new forms of decentral value generation, commonly accepted decentralized governance rules, risk management practices, and compliance frameworks are necessary.

From a technical point of view, the scalability of blockchain-based systems is one of the main challenges. It remains unclear how to guarantee security at scale, governance at scale, or risk management at scale in decentralized environments. The ability to connect an increasing number of users, to handle and increasing number of transactions and doing this is a robust and resilient way that meets compliance requirements is one of the most urgent topics to mature blockchain as technology. And finally, what is still missing are global standards as well as national and European regulatory frameworks that are essential to safeguard investments into blockchain innovations and applications.

DANISH BLOCKCHAIN INDUSTRY CLUSTER

Clusters are an important element in competition and competitive strategies in the context of a global economy. Clusters improve the competitiveness of a nation or region, with the capacity of industries to become embedded in a deep network supporting concentrations of companies, institutions, customers and complementarities. Clusters allow member companies to operate with greater productivity by improving the supply of inputs, skills, access to specialized information, technology and specialized institutions. In addition, clusters drive innovation and stimulate the creation of new businesses by providing conditions of access to fully functioning capital markets.

While it is too early to say which will be the driving forces for a blockchain industry cluster in Denmark, there are several startups and established companies in the Greater Copenhagen region that may indicate the emergence of a blockchain industry cluster. The overview of the Danish blockchain cluster illustrated that most identified blockchain-related entities can be classified in three main sectors: Fintech, professional services industry and IT, and the maritime shipping and transportation industry.

Unlike in the Netherlands or Switzerland there are no large-scale public sector initiatives in Denmark attempting to establish a blockchain eco-system for blockchain approaches let alone blockchain clusters.

The lack of major blockchain initiatives among the Danish banking industry stands in contrast to the lively and prosperous Fintech and blockchain start-up scene in Denmark. The CPHFINTECH 'cluster' is internationally recognized for innovative solutions, but these innovations have yet to make major inroads into the Danish banking and insurance industry.

Industry initiatives typically focus on direct effects of blockchain solutions to reduce operational risks and ultimately costs through increased transparency and auditability.

There is little doubt that blockchain will be a significant shaping factor for future supply chains both from a user as well as service provider point of view. Current initiatives like Tradelens (Maersk/IBM) and Blockshipping (container management) build directly upon blockchain capabilities like transparency, authenticated event log records, immutable records, resilience in their solution architecture.

BLOCKCHAIN SURVEY AMONG DANISH INDUSTRY

An empirical analysis based on a comprehensive survey among Danish companies was performed in January and February 2019. The goal was to get insights into the current assimilation state of blockchain technologies in Denmark as well as of drivers and hurdles in future developments.

A quantitative research methodology was chosen to be able to capture current interrelationships and numerical characteristics in the larger scope of the Danish economy. Using a fully standardized questionnaire, central company data as well as data on the current and planned use of the blockchain were queried. The target group were companies based in Denmark from small and mid-sized companies all the way to multi-national corporations.

The selection of the specific sample and the implementation of the survey was carried out by Danmarks Statistik, the Danish national statistics office. From the national industry register, 28 sectors were selected for the survey, clustered into six groups:

1. trade
2. information & communication
3. transportation
4. knowledge based services
5. manufacturing
6. financial & insurance

Those six sector groups are comprising the most important private industries in Denmark. The analysis drew a stratified sample from the selected sectors. The data sample with a response rate of over 44 percent of the 3,000+ companies surveyed allows for a very robust empirical analysis of the innovation dynamics and blockchain activities within Danish industry. The survey comprises questions regarding the digital strategy of the company, the innovation environment and digital position of the company, and used performance measures as well as questions more specifically geared towards blockchain assimilation such as current engagement and challenges with blockchain projects, potential areas of use of blockchain as well as level of blockchain know how and expected future engagements and effects of blockchain on the company and as well as industry.

Some key findings will be highlighted in the following:

- Both large and micro-sized companies are sharing similarities in percentages of knowledge, with comparable knowledge on blockchain. Large companies have the resources to invest in research and innovations such as blockchain technologies, while micro companies, including start-ups are inspired by blockchain and digitally born. Mid-sized companies are in between and have a less clear orientation and knowledge when it comes to blockchain innovations.
- While 75 percent of surveyed companies reported to possess only some knowledge about blockchain, eleven percent reported that they have already engaged in some way with blockchain, such as done a Proof of Concept, or explored its applicability for their purposes.
- The industry that reported to have most knowledge about blockchain has been the financial services industry, with around 77% reporting to have experience with it. However, a similar high percentage was found for the information and communication technology sector in Denmark.
- Other industries such as the transportation and manufacturing industry report around 30-40 percent of at least some extent of knowledge about blockchain technology. The logistics and shipping industry has taken a great interest on implementing use cases of showcasing how the shipping industry could benefit from blockchain by registration and issuing certificates on the blockchain.
- IT top performing companies are ahead of competition in terms of being able to inform themselves and becoming more knowledgeable about blockchain technology. In addition, at least 33 percent of top performers have extensive or at least some knowledge about blockchain. In contrast, IT companies that can be characterized as followers reported only in 18 percent of the cases to have the same level of knowledge.
- If one compares innovation leaders with innovation followers in the surveyed sample, strong innovators have more than twice as many blockchain-related projects than the followers, where only 13 percent exhibit some experience and knowledge when it comes to blockchain.

COMPARATIVE ANALYSIS OF THE EFFECTS OF BLOCKCHAIN IN SELECTED COUNTRIES

In addition to focusing on the blockchain readiness of Danish industry, this study also comprises an overview of blockchain activities as well as lessons learned from other countries or regions of the world.

A key learning is the widespread level of activities in using blockchain, that for example lead to innovative services not previously available to society. Another learning is that several governments strive towards leadership in the global blockchain competition by providing economic support as well as legislative readiness for blockchain innovations in their countries. Denmark is in this regard not in a leading position.

The comparative analysis considered eleven different countries as well as the European Union to assess their blockchain strategies and readiness. For most of the reported countries the leading industries interested in applying blockchain were the financial services industry, the supply chain industry and trade, and the IT industry. Some countries seem to have a high engagement across all sectors, such as Australia, Canada, China, Russia, Singapore, Switzerland, the US, or Estonia with its showcase example as leader in public sector digitization. Countries like Switzerland or Liechtenstein try to position themselves as “crypto valley” or “crypto country” by creating a positive investment and development environment for blockchain ventures.

Countries such as China, Russia, Canada, Estonia, Switzerland, Singapore, as well as the EU offer different types of support services to stimulate the formation of a blockchain economy, essentially through adaptations of legal frameworks, financial zones or direct financial stimuli. These countries often also seek to protect interests and increase influence in international standardization bodies.

BLOCKCHAIN FUTURE SCENARIO ANALYSIS

While we are still commonly use the term blockchain to describe the technology and its economic impact, we most likely will talk about Distributed Ledger Technology Systems, or in short DLT systems, in the future. To obtain insights into future potential scenarios and developments in the assimilation of DLT systems in Denmark, four scenarios have been selected on future blockchain utilization:

- Aspirational Scenario: Efficient public-private collaboration on DLT systems assimilation
- Transformational Scenario: Strong industrial lead in DLT initiatives
- New Equilibrium Scenario: Global competition and dominance
- Collapse Scenario: Distributed Ledger Technology for niche applications

As for the “aspirational scenario” about an efficient public-private collaboration, the highlighted opportunities created new job opportunities along with entirely new value creation networks in different industries and Danish labor market. The highlighted risks for this scenario were the lack of qualified experts for rolling out these new networks.

The transformational scenario is about having a strong industrial lead on DLT innovations, with opportunities for the Danish labor market that would not only create new jobs in the public and private sector, but also improved transparency in all kinds of processes. On the other hand, the risks here could be that the assumed lack of integration of governmental services could also reduce the ability to realize cost savings in comparison to other countries who have already done this.

The third analysis focuses on a new equilibrium scenario, which considers the global competition and dominance perspective. This scenario highlights the opportunities that could relate to DLT and further investments in legacy technologies, which could attract

innovators and establish a strong labor market. As for risks, if the Danish industry would lose business to other countries that are integrating DLT-based systems faster and more comprehensive, it could have negative consequences for the Danish labor market, as well as potentially lead to “de-skilling” of the national work force, as the highly wanted DLT-skilled workers would travel to countries with DLT-related opportunities.

The last and most grim scenario is the collapse scenario, where DLT solutions are only applied in some niches. This scenario showcases the worst-case scenario, where the opportunities would be small, and the risks would be high. DLT-driven systems would negatively affect efficiency and led to diminishing revenues and job opportunities.

Overall, these scenarios provide a comprehensive overview of potential outcomes of the adoption of DLT for the Danish labor market and supply chain industry providing a foundation for future strategies and decisions. There is a need for having a strong industrial lead to inspire and guide the lawmakers to focused action.

CONCLUSIONS

Most identified blockchain-related entities can be classified in three main sectors: Fintech, professional services industry and IT, and the maritime shipping and transportation industry. In those sectors one can find most blockchain activities in Denmark.

Unlike in the Netherlands or Switzerland there are no large-scale public sector initiatives in Denmark attempting to establish an ecosystem for blockchain approaches let alone blockchain clusters.

The Copenhagen Fintech cluster is internationally recognized for innovative solutions, but these innovations have yet to make major inroads into the Danish financial services industry. The lack of major blockchain initiatives among the Danish banking and insurance industry stands in contrast to the lively and prosperous Fintech and blockchain start-up scene in Denmark.

Industry initiatives typically focus on direct effects of blockchain solutions to reduce operational risks and costs through increased transparency and auditability. There is little doubt that blockchain will significantly shape the future supply chains. Current Danish initiatives such as Tradelens or Blockshipping build directly upon blockchain capabilities like transparency, authenticated event log records, immutable records, as well as resilience in their solution architecture.

What is limiting a widespread assimilation of blockchain solutions so far is the lack of standardized open interfaces to existing legacy systems.

From the data we were able to observe differences between companies that can be classified as “top performers”, “digital leaders”, and “strong innovators” in comparison to companies that do not fall into these groups, the “followers”. With that, at least 33 percent of top performers had some extent of knowledge in comparison to followers, where only 18 percent claimed to possess some knowledge on blockchain technologies. As for strong

innovators, 40 percent claimed having at least some extent of knowledge and also reported that 40 percent having already some sort of engagement with blockchain technologies. This is remarkable, given that blockchain technologies are still in their infancy.

Another impressive result was that 15 percent of large companies and twelve percent of medium-sized companies use blockchain technology at least to some extent already. This is a very positive outcome and base for further development, given the early stage that the different DLT and blockchain technologies are in. In addition, around 34 percent of companies expect to apply blockchain solutions in the next two years. In other words, blockchain technologies seem to become soon mainstream solutions used by a large number of companies in Denmark.

The largest share of companies that expects an influence of blockchain-based innovations anticipates it to affect their business strategies or models. This is supported by almost half (48 percent) of the companies stating that blockchain will affect their business strategies this at least to some extent. On the other hand, the share of companies that are afraid of blockchain as it might adversely affect the companies' business model is rather low with around 10 percent. This can be interpreted that the majority of Danish companies perceive blockchain technologies as an opportunity, rather than a threat to their business.

A lack of standardized solutions and of experts is seen as the most important impediment for assimilation blockchain solutions at the moment. Standardization activities and more training and education programs that educate blockchain experts seem to be required.

Challenges for a broader assimilation of DLT systems also arise from legal issues. Somewhat surprisingly, top performers, as well as strong innovators, and digital leaders regard legal challenges in applying blockchain solutions as a bigger issue than their respective follower-groups. As they are also the one's with more blockchain experience, it can be very well the case that they have a better-informed understanding and awareness of the regulatory issues around blockchain technologies.

In general, the higher the blockchain-knowledge of a company, the higher the likelihood that it expects that blockchain-based systems will become a part of their business, already within the next 2 years. What is striking here is that even with in-depth knowledge about the pros and cons of blockchain solutions of today, companies with knowledge expect a swift integration of blockchain, compared to their followers.

One should highlight that regarding the perceived innovation climate in Denmark, smaller companies have reported that they see more issues with the innovation climate in contrast to larger companies. This is an alarming outcome, as any kind of hindering reasons for entrepreneurs to get started may severely hamper Danish industry to innovate through bottom up movements.

Further significant insights from this comparative analysis are the following:

- In the case of blockchain top performers the digitalization level of the company influences the most the blockchain assimilation with respect to all other subsets: excellent company performances and a high digitalization level are prerequisites of high blockchain assimilation.

- The IT and business alignment of the company influences the most the digitalization level in the case of blockchain-strong innovators. Thus, if IT and business strategies are strongly aligned, then the companies who are more open to innovation, exhibit a higher digitalization level.
- In the case of blockchain digital followers, the lack of blockchain knowledge among the top management blockchain know-how has the strongest effect on the degree of blockchain assimilation.

Researching the effect of an emerging technology such as blockchain on industry on macroeconomic level comes with some challenges. While the Danish industry as well as blockchain startups are showing all the signs of a prosperous, and blockchain-affine development, it is not easy to locate companies within the emerging blockchain industry cluster in Denmark. We found that some internationally well-known and successful 'Danish' blockchain companies such as Chainalysis or MakerDAO do not have their headquarters registered in Denmark. While this does not diminish their importance as blockchain innovation engines for the country, it makes it more difficult to economically assess the blockchain industry cluster, if key players are not registered in Denmark, are taxed abroad, or have many employees located elsewhere. It also kicks off a thought: Why do successful blockchain companies not register primarily in Denmark?

Likewise, our study did not give full justice to the several blockchain initiatives rolled out within the public sector in Denmark, as our focus was on the private industry. Thus, the economic implications due to the innovative use of blockchain solutions for the registration of vehicles in Denmark or the national ship registry is not covered. However, one could also counter-argue that public or governmental support is somewhat meagre when one compares with for example the Netherlands or Austria - countries not included in the report itself, but relevant here. These countries focus on an active development of a thriving public private stimulating structure as the perception is that to gain benefits in the total ecosystem, it is necessary to stimulate the total ecosystem to spread out direct experience with the new technology in the community stimulating wide-spread creativity.

Based upon the results of this study, it is the belief of Danish industry that blockchain will make major inroad in many companies improving business processes already within the next two years. Given the huge number of different application fields for blockchain and DLT systems in general, the technology is most likely to become part of the Internet as we know it as well as will give rise to a completely new form of Internet allowing for autonomous proactive systems as IoT and automatic vehicles. Thus, blockchain does not only play an important economic role, but also an important societal role.

Together with artificial intelligence, it most likely will give rise to "digitization 2.0". With the introduction of DLT systems, value transactions without dependence on or trust in third parties became feasible, enabling companies to establish new value streams.

Therefore, the "internet of values and trust" is often mentioned in this context. DLT systems and blockchain are not "yet-another-technology" but will affect societal aspects and fields of politics that are typically not affected by digital technologies. Certain promises of blockchain such as certainty, trust, truth, transparency and so on are so fundamental

that it is not possible today to fully grasp the lasting potential impact of blockchain on society and industry.

Thus, applying blockchain is not just a matter of getting the typical benefits from a new technology providing better effectiveness or efficiency. DLT systems may provide totally new services, from intelligent cities where blockchains offer new possibilities for sharing services, to intelligent transportation services all the way to smart energy grids. These new public blockchain-based services provide business opportunities for companies from developing pilots to operating public services. Blockchain may also help improving access to capital markets or may provide banking services for unbanked user groups that help increasing markets.

The examples illustrate that blockchain technologies may open new opportunities which go beyond traditional business areas. A key learning here is the widespread level of possible activities from using blockchain, many of which are innovative, offering services not previously available to society. The opportunities lie in developing and applying blockchain welfare solutions that also will help to develop the competencies for further use-cases and prototypes.

RECOMMENDED ACTIONS

There is a need for education on all levels, especially at the executive level, to develop the needed blockchain mindset to evaluate business opportunities and challenges around potential blockchain solutions. The need for courses covering technical and economic aspects of the emerging blockchain economy for developers and executives at high level will allow to discover and realize business opportunities. A blockchain mindset will also sharpen the needed end-to-end perspective to deal with the complexity of DLT systems. What is needed is blockchain know how that enables executives to make evidence-based decisions to launch new products and services. Executive understanding and insight into the blockchain peculiarities that can be directly translated into benefit is one of the key findings of this report. This is further emphasized by the finding in this report that in the case of blockchain top performers, the digitalization level of the company influences the most the blockchain assimilation with respect to all other subsets: excellent company performances and a high digitalization level are prerequisites of high blockchain assimilation. The need for thorough education of highest quality is a must for visualizing and achieving global leadership in the field and it needs to get developed and financed adequately.

A stimulation of the blockchain industry and cluster is needed. The Danish society including industry and the public sector needs to take a global perspective, similar to countries such as Estonia, Singapore and Switzerland. Unlike in the Netherlands, Switzerland or Austria there are no large-scale public sector initiatives in Denmark attempting to establish an ecosystem for blockchain approaches let alone clusters. These countries focus on an active development of a thriving public private stimulating structure to gain synergy effects.

The solid evidence from this report on the need for decision makers in industry and politics to clarify the future positioning and strategy for blockchain development and assimilation in Denmark. The focus is on how Denmark can build upon that strength and steer its blockchain development into the future. It is recommended to launch suitable initiatives and to stimulate cooperations between relevant ministries and other public entities.

An area that requires improvement is the innovation climate in Denmark. Smaller companies perceive the climate as less fortunate in contrast to larger companies. If the aim is to improve the blockchain adoption particularly among small and mid-sized companies, one would have to analyze in more detail which aspects of the innovation climate in Denmark are especially perceived as hindering factors when it comes to blockchain. Some questions need to be investigated, such as why several successful Danish blockchain companies are not registered in Denmark. It might be relevant to analyze this to avoid a potential drainage of Danish talents.

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A BLOCKCHAIN BASICS

In recent years, blockchain technology has garnered a lot of attention from several industries for its potential to disrupt the way in which we trade and trust each other in an increasingly globalized world. In brief, a blockchain is a distributed (shared, decentralized) digital ledger. It uses cryptographic algorithms to verify the creation and transfer of digitally represented assets or information over a peer to peer network. An innovative combination of distributed consensus protocols, cryptography, and in-built economic incentives based on game theory is used to govern the network (Maupin, 2017). However, the technology is still in an early stage of development and we are still only at the beginning of its widespread use, as its adoption still faces several challenges.

Blockchain has attracted great interest not only from the IT industry, but also from other industries and governments around the world. However, the term is also associated with a hype driven in particular by the growth of Bitcoin, the first application of blockchain, whose market value increased from less than \$20 billion to more than \$200 billion in the course of 2017 (Carson, et al., 2018), before its value dropped sharply soon thereafter. However, blockchain as underlying technology allows for countless other areas of application which go far beyond cryptocurrencies and may impact our society in novel ways and sectors including, but not limited to, healthcare, transport, banking, energy and government.

In this report, we introduce a general overview of this novel technology. In section two we present its origins and describe its first application, the cryptocurrency system Bitcoin. The importance of blockchain and its potential through the provision of technology-based trust are also presented. To provide a better understanding, the fundamental principles, properties and classification of blockchains are discussed in section three. Some potential uses in the finance, supply chain and healthcare industries are presented in section four as well a vision of how blockchain may impact the global economy. Finally, we describe possible solutions for the main challenges of blockchain technology for a general adoption.

Overview

History

Blockchain technology is characterized by the use of advanced encryption methods and its origins may be associated with the year 1991 when two researchers published the paper “How to Time-Stamp a digital document” (Haber & Stornetta, 1991). This work introduced a technology that allowed a server to take a document, time-stamp it, and link it to the previous document. The link pointed to the data in such a way that if the data changed, the pointer would become invalid thus making it a tool for validating the document’s data. This concept set part of the basis of the blockchain technology, but it was not until 2008 when a practical blockchain application was conceived. In October of that year an anonymous person, or group of persons known as Satoshi Nakamoto published the paper “Bitcoin: A Peer-to-Peer Electronic Cash System” introducing a lead innovation, a proposal for the solution of the double spending problem in digital assets. This paper proposed a form of digital currency that allowed peers in a peer-to-peer network transact with it in a direct way without going through any financial intermediary. Approximately three months later Nakamoto released the first bitcoin software that started the network and the first bitcoin units.

Besides of introducing a major breakthrough and potential of disruption in the financial services industry, Bitcoin opened the door for a new wave of innovations in different areas. Around 2014 the attention started to deviate from Bitcoin to its founding technology, blockchain, as it allowed for a whole lot of different and new applications. That year, Vitalik Buterin introduced Ethereum and its use with Smart Contracts (Buterin, 2013) and other similar platforms emerged using the intrinsic features of this technology. Since then, a multitude of use cases for blockchain technology or distributed ledgers have been presented and numerous implementations of the technology are in development.

Today, large companies are creating consortiums around this technology and invest significantly in its research and development. At the end of 2015, under the initiative of IBM and other partners, it was announced that the Hyperledger Project, led by The Linux Foundation, would be created to support the collaborative development of the technology (Hyperledger, 2016). To this date, it has more than 200 active members and a set of blockchain open source software tools for companies. The Enterprise Ethereum Alliance aims to the creation of enterprise-grade software based on the Ethereum platform. As of July 2017, more than 145 companies including Microsoft, Cisco, Intel, JP Morgan and Toyota were part of the consortium (Hyperledger, 2017). These are just two examples out of the more than 40 consortia identified by Deloitte by mid-2017 (Deloitte, 2017). Despite this important movement, the technology is in a very early stage of development and the real applications are still very limited in number and coverage.

Blockchain Fundamentals

In very simple words, a blockchain is a ledger with a set of special features that provide several advantages over a traditional registry log. In its most basic form, blockchain technology is a “decentralized database that stores a registry of assets and transactions across a peer-to-peer network. It’s basically a public record of who owns what and who transacts what. The transactions are secured through cryptography and over time that transaction history gets locked in blocks of data that are then cryptographically linked together and secured.” (Warburg, 2016). That gives rise to a highly tamper-resistant ledger that serves as a technological source of truth among the peers.

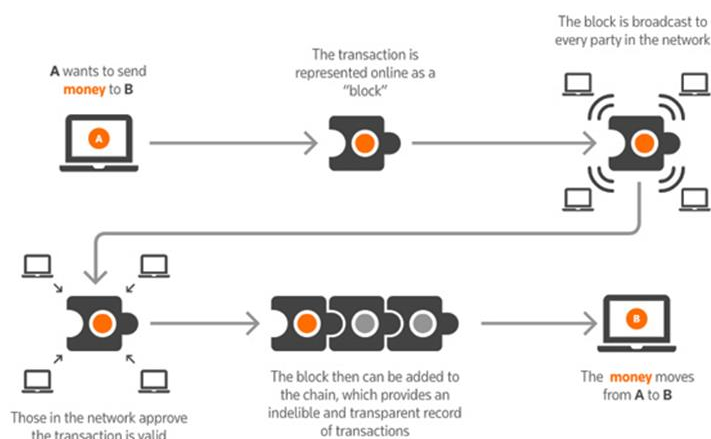


Figure 1: How a transaction works in a blockchain network (Thomson Reuters, 2018)

A transaction in a blockchain network is stored in the ledger only if a set of peers validate the transaction through a mechanism called consensus algorithm. As an example, we can say that person A wants to send money to person B. When the money is sent, a block containing the information of the transaction is created. This transaction is broadcasted to all peers in the network who validate it. In case it is approved the block is added to the chain and the transaction is settled. This means, the ledger will register that person A no longer has the money, but person B.

The Role of Trust

Trust is the foundation on which most of our relationships as human beings are based. When we visit a doctor, consult a lawyer or choose a representative, it is trust that allows us to interact (Evans & Krueger, 2009). When we conduct a business transaction in cash, for example selling an asset, this trust is based on the fact that the buyer will get the asset and we will get our money at the same time. From that moment on, our money can be used for any other transaction. However, when it is not a cash transaction, trust is not a direct

relationship. This is where trusted third parties like banks come into the relationship providing trust and expanding the spectrum of transactions we can make, the places where we can make them, and people with whom we can make them.

Despite this, the trusted third-party model is inefficient in several ways. First, it generates transaction costs for participants that nowadays account for billions of U.S. dollars every year and eventually exclude a significant number of the world's population, especially in developing countries. The model centralizes information and concentrates high power in third parties like financial institutions and makes them sources of constant attacks from hackers. Additionally, the processing of information by third parties introduces delays in transactions and may be limited geographically, all this creating friction in transaction processes.

Blockchain technology decentralizes information storage, reduces or eliminates the need of third parties and provides trust through technology and mathematics. Although Bitcoin was the first application to allow a global exchange of digital assets without the need for intermediaries, it is not the only one. Currently, different applications and platforms are being developed to reduce or eliminate friction in any transaction-related process. Blockchain is presented as an innovative alternative that opens the door to new ways of interaction where trust is provided by technology. This feature provides a huge potential to our society that may be compared with the introduction and general adoption of the internet.

Bitcoin as First Application

Money is a mechanism that allows us to express transactional values between people and is one of the oldest trading tools in human history. Since antiquity, coins were created to be common exchange elements in a specific context (a tribe, community, country or kingdom) that allowed the trade of goods thus promoting the market economy. These were issued by kings or emperors and a central authority controlled the supply of currency according to the demand and need for physical money. Throughout history these money issuance and control authorities have accumulated great power and are now an integral part of our economy. However, without proper regulation and under competitive pressures, these entities may act inappropriately with serious consequences for the economy. This was the case that ended up creating the global financial crisis of 2008 (Blundell-Wignall, et al., 2009), (Murphy, 2008).

At the peak of this crisis, Bitcoin was presented as an alternative to the money management model in our society. Satoshi Nakamoto created an open source software called Bitcoin that he subsequently distributed and that allowed anyone to be part of a network in which a digital currency can be exchanged freely and directly among peers that participate in it.

This development introduced great innovations that make it a useful and valuable technology. On the one hand, it avoids the creation of digital money out of nothing (the solution to the double spending problem) since a bitcoin is not a digital file that can be

“copied and pasted” but instead is a transaction record. On the other hand, it allows registering digital transactions in such a way that their subsequent (unauthorized, “hacking”) modification requires so many resources that it is considered practically impossible. Additionally, and most notably, Bitcoin allows for the first time ever the exchange of money in a global economy without the intermediation of a central financial entity or a single administrator.

Why is Bitcoin considered an alternative to traditional money?

Unlike traditional money, commonly known as fiat, Bitcoin is not issued or controlled by a central authority. Instead, Bitcoin is “mined”, that means, it is created by members of the network through a process of solving mathematical problems that at the same time allows validating transactions made by other users. Thus, small amounts of bitcoin are issued every time a group of transactions are validated.

Similarly, Bitcoin offers users more control over their money (Bitcoin.org, n.d.), because it allows any person with the proper software to send and receive any amount of money no matter his location and without limitations of schedules or the tax limits that a traditional transaction has. Transaction costs are relatively low and are not associated with the amount of money transacted. Today, traditional international transactions can be expensive, cumbersome, error-prone and may take days or weeks to complete if they involve different currencies (IBM, 2017). However, although Bitcoin has the potential to reduce costs and speeds transactions, it is still not a widely accepted payment method. In practice, transaction fees have increased significantly over the last years making bitcoin expensive for small transactions (Robert, 2017). The Bitcoin system can handle just a few transactions per second so traditional banking systems have still a performance that is hundreds or thousands of times better (Möbert, 2018). Another significant aspect, although controversial, is that the Bitcoin network does not directly associate transactional information with personal information, offering a certain degree of pseudo-anonymity.

From the technological point of view, Bitcoin offers trust, but this is not centered on a single authority. This feature has attracted a significant number of developers who are even more motivated by the fact that the Bitcoin system is open-source. They collaborate with the software so the network is improved by the community itself instead of a company or organization, however any change must be approved by consensus or otherwise it is not adopted.

Despite the mentioned advantages, there are aspects that have prevented the general adoption of Bitcoin and its widespread use in daily commercial activities. Although bitcoins are created at a decreasing predictable rate and are limited to a total amount of 21 million (Bitcoin.org, 2018), it is subject to a high level of volatility. At present, its price changes considerably in terms of time and value compared to traditional currencies such as the dollar or the euro. Such volatility is caused by a varied set of factors including deregulation that promotes speculation, the influence of the media on the hype of cryptocurrencies, the reluctance of institutional investors to participate in these markets (Jay, 2018) and studies that claim there has been market manipulation leading to the growth of Bitcoin prices

(Nathaniel, 2018). In addition, several exchanges and pioneer companies have suffered hacker attacks that have led to the loss of more than 2.3 billion dollars causing sharp price drops (Tim, 2018). As a result of this volatility it is difficult for traditional traders to include Bitcoin and other cryptocurrencies in their daily operations, slowing down their general adoption.

Bitcoin as the first real blockchain application, something comparable to what the email was for the Internet, is just one application of many. Nevertheless, it is its foundational technology that allows a wide range of new applications that go beyond cryptocurrencies and opens the door for disruption of many business models in different industries. However, just as any innovation, it presents challenges that we will discuss in greater detail in section 4.3.

Blockchain Deeper Concepts

As mentioned before, blockchain is a ledger with very special features. To discuss their properties, it is necessary to understand its role in our way of doing business. Historically, ledgers have been the basic instrument to demonstrate the ownership of an asset (Berg, et al., 2018). In ancient times, ledgers were guarded and updated by a single authority that served as a center of trust for the people and for that reason it was the kings who controlled them. Problems arose when it was necessary to make a transaction with another kingdom in which case it was necessary for the two kings to update their records simultaneously. Actually, this is very much what happens today. We need the validation of different authorities to be able to carry out transactions on a global scale. Blockchain is an alternative to this model due to the novel combination of former technologies (International Finance Corporation, 2019).

Before this report continues discussing the properties of blockchain technology, it is necessary to clarify that the technology is in an early stage of development and new types of blockchain platforms and solutions are frequently materializing. And although this report uses blockchain as central term, it is worth noting that the more precise term would be distributed ledger technologies, as some ledgers have similar characteristics, but do not store data in blocks chained together. While Bitcoin and Ethereum are the two most important blockchain protocols (Bryant, 2017), there is an increasing number of other protocols that offer a variety of additional or different features, use different consensus algorithms, transaction verification techniques and ways to store information. In the following, we present the most fundamental and relevant concepts that characterize the blockchain technology in general.

Decentralization

With blockchain the transaction record belongs to all the network participants instead of belonging to a single centralized entity. Each participant or node in the network regardless of its geographic location stores an exact copy of the ledger. Each time a transaction is carried out and approved, all the nodes update the ledger thus maintaining a distributed and synchronized copy. This architecture introduces a high level of tolerance to failures, which means that the information will remain intact in the rest of the network even if a node fails, is hacked or disappears. In this way a central authority is not necessary and the main disadvantages of the centralized model are eliminated: proclivity to failures, having a single center of attack by hackers or malicious agents and of course possible abuses in the handling of information (The Linux Foundation, n.d.).

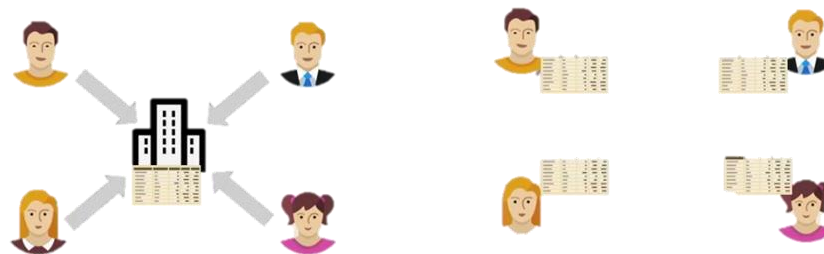


Figure 2: Decentralization in a network (Harrison, 2016)

In addition to having a decentralized network architecture, blockchains are also considered to be decentralized politically. This means that there is no single control entity – in fact, nobody controls them, and nevertheless they are logically centralized since the network itself behaves as a single computer (Buterin, 2017).

Immutability

One of the characteristics of blockchain is its condition of immutability, that is, the property that makes it virtually impossible to make modifications to what has already been stored. Nevertheless, "When people say that blockchains are immutable, they don't mean that the data can't be changed, they mean it is extremely hard to change without collusion, and if you try, it's extremely easy to detect the attempt." (Anthony Lewis, Director of Research at Corda R3, (Lewis, 2016)). There are two aspects that make up the property of immutability. On the one hand, unlike a traditional database, a blockchain by design only allows to read and add records, these cannot be modified or deleted. Therefore, in case of registering an erroneous transaction, this cannot be reversed. A new transaction must be issued to correct the first one and in any case, both are registered (Manav, 2018). Thus, a blockchain is an ever-growing transaction ledger (Lemieux, 2016).

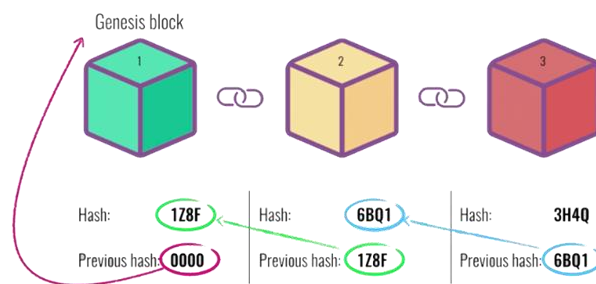


Figure 3: Block forming structure (Savjee, 2017)

The other aspect that guarantees immutability is the way in which information is stored. All transactions are stored in the form of blocks containing precise information about the previous block. This information is called hash and it is a unique identifier of the contents of a block (Deloitte, 2016). In this way, a new block is linked to the previous one through a hash creating a chain with its successor, hence the name of the technology (TechTerms, 2018). The most important aspect of this link is that changing a data contained in a previous block would cause all hashes to change making any manipulation evident. In addition to requiring a huge amount of computing power, modifying a block would require modifying the hashes in all the subsequent blocks and making this modification in more than 51 percent of the nodes of the network. Therefore, in networks such as Ethereum or Bitcoin with tens of thousands of nodes, a tampering is considered virtually impossible (The Linux Foundation, n.D.).

Security

The blockchain networks are considered highly secure since in addition to providing immutability they incorporate data protection mechanisms through cryptography (Miles, 2017). Although this technology is not new, cryptography is basically a technique for transmitting information (called secret) in a hidden or coded manner so that it is unreadable or incomprehensible for those who do not know its code (called key) (The Linux Foundation, n.D.). Blockchain uses this technique to store transaction information in the ledger in a secure manner. Additionally, blockchain requires each transaction to be signed by whoever performs it, attackers cannot forge a transaction unless they steal the signature (private key) of someone else. This provides a high level of security making the blockchain networks reliable (Jin, et al., 2017).

Consensus Algorithms

Since a blockchain is composed of a significant number of nodes, it is necessary to have a mechanism to synchronize the information and reach an agreement about which transactions are saved in the ledger and which are not. This mechanism is called a

consensus algorithm (The Linux Foundation, n.D.). In the first blockchain, Bitcoin, the consensus mechanism used is called Proof of Work and consists of a way to generate mathematical puzzles that are difficult to solve but whose solution is easy to verify. Special nodes called miners are responsible for solving these puzzles and writing blocks with transactions validating them. By solving these puzzles, they are awarded with small amounts of bitcoins. This mechanism makes an attack perpetrated to modify or eliminate transactions require a huge amount of computing power improving the security of the network (The Linux Foundation, n.D.).

However, Proof of Work requires a level of energy consumption that grows with the network. This represents serious scalability issues (de Vries, 2018). For this reason, new consensus algorithms are studied as an alternative on different platforms. Some of them are Proof of Stake, Delegated Proof of Stake, Proof of Authority, and Delegated Byzantine Fault Tolerance (Bach, et al., 2018).

Smart Contracts

A blockchain network is physically a set of nodes which are, for example, computers, cell phones or any device with computing capacity that communicate directly with each other. In a simple way, the network itself can be described as a computer with a large computing power that stores many copies of the same ledger (Laurent, 2017).

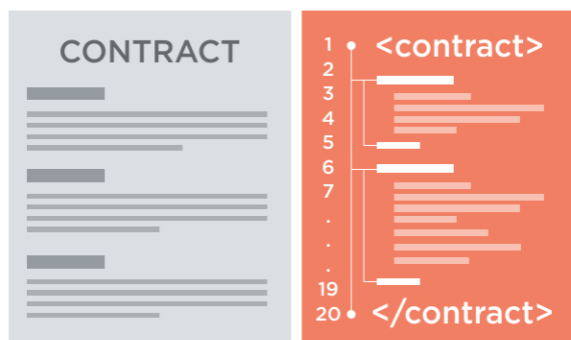


Figure 4: Smart Contract (MrAdon, 2017)

One of the features that triggered the potential of blockchain is the ability to "install" software on this computer. We know this software as Smart Contracts and they are basically a set of rules that are executed automatically after the occurrence of an event that we have previously defined. A Smart Contract is essentially business logic running in a blockchain (Hyperledger, 2018).

„Smart Contracts are programs on the blockchain that control digital assets. Smart contracts have been around for twenty years, but their use makes blockchains a lot more versatile“ (Digfin, 2017).

More precisely, a Smart Contract automates the execution of transactions in a blockchain network in a way that guarantees that all its participants follow the same rules. A simple example consists of a network in which doctors and patients participate and in which medical records are stored. A Smart Contract can be designed so that a patient can see his records but is not allowed to modify them and at the same time a doctor cannot modify the records unless the patient gives his consent.

Smart Contracts provide speed and accuracy, trust, security and savings (Nigel, 2018). The potential offered by Smart Contracts greatly expands the number of real applications that can improve the way people and organizations interact.

Types of Blockchains

A general consensus over the classification of the different types of blockchains has not been reached. Nevertheless, one commonly adopted approach considers three types of blockchains: private, public and federated (BlockchainHub, n.D.).

In essence, blockchains can be classified along two dimensions: (1) access to transactions—that is, the ability to read blockchain data and to submit new transactions. In public blockchains, all nodes can read blockchain data and submit new transactions. In private blockchains, only nodes that have been predefined by a central authority can read blockchain data and submit new transactions. The other dimension is (2) access to transaction validation—that is, the ability to participate in the creation of new blocks, for instance through Proof of Work or Proof of Stake algorithms. In permissionless blockchains, all nodes can validate transactions. In permissioned blockchains, only nodes that have been predefined by a central authority can validate transactions. A permissioned blockchain can be both public and private (Peters & Panayi, 2015).

Permissionless public blockchains allow any individual to join the network by simply downloading and executing the proper software. In this case, their computer can store a copy of the entire ledger and submit transactions to be approved by other nodes. Additionally, a node can also act as a validating node and a writer of blocks, this means acting as a miner in the case of the Bitcoin blockchain. Examples of this type of networks are the Bitcoin and Ethereum blockchains.

Permissioned public or consortium blockchains are organized and operated by groups of organizations which determine who can participate in the network as well as who validates transactions and under what consensus protocols. At the same time, the consortium can decide who has the right to read or write in the ledger and whether this restriction is limited to the network participants or not. An example is the Corda platform (Brown, 18). Restricting the number of participants reduces transactions costs and data redundancies and allows levels privacy specially required in a business environment. Another example is Ripple, a remittance network and currency exchange (Ripple, 2018a). Hyperledger is a set of blockchain tools that allow to create permissioned blockchains that fall into this category (Hyperledger, 2016).

On the other hand, permissioned private blockchains are blockchains operated and controlled by a single company. The access to read and write is fully controlled by the company but can be extended outside of it. This type of network may not be considered as a blockchain as is not politically decentralized (see Buterin, 2017), nevertheless as mentioned before, there is no final consensus over the definitions and classifications.

Apart from considering the number and type of controller participants and verifiers, another level of blockchain classification can be considered according to the permissions to read and write in the ledger. A permission-less blockchain is a network in which any participant can openly read and write while a permissioned blockchain limits the number of participants with such rights.

Combining the two classification schemes the following classification graph can be presented:

By access to transactions	By access to transaction validation	
	Permissioned	Permissionless
Public	All nodes can read blockchain data and submit transactions. Only predefined nodes can validate transactions.	All nodes can read blockchain data and submit transactions. All nodes can validate transactions.
Private	Only predefined nodes can read blockchain data and submit transactions. Only predefined nodes can validate transactions.	Not applicable

Figure 5: Blockchain classification scheme. Modified from (Peters & Panayi, 2015)

Use Cases and Potential

A look at the media of recent years shows a growing interest in blockchain technology. The reason why this interest is going beyond the technological field is blockchain's capacity to disrupt many aspects of our society. Its application areas go far beyond electronic payments and could potentially positively impact our environment. In this section we will describe how the blockchain can generate positive impact through applications in three main areas: finance, supply chain management, and medicine. Although there are a large number of use cases that have been established, most of them have only been developed as proof of concept at beta or alpha stage (Panetta, 2017) and some as prototypes. However, very few have reached the commercial production phase.

Finance

The area of finance is probably the sector with the most activity in the blockchain ecosystem and the one with the biggest market value in the last year (Statista, 2019). This is partly because the first blockchain application was the Bitcoin electronic payment system. However, another important reason is the complexity of the financial world that involves numerous parties and presents many opportunities for improvement. Some of the application examples include:

Cross-border payments. Every year cross-border payments worth more than 20 trillion dollars are made (Accenture, 2018). Alone in the B2B transactions, there are fees at both ends of the parties involved and sometimes at other stages of the processing (Myler, 2017). Additionally, the transaction may take several days, a time in which the money is not available to the issuer or the recipient. Peer to peer applications based on blockchain can allow a person to send and receive money across different countries at a faster rate, with lower costs, offering greater transparency (traceability) and reducing risks. As an example, Ripple is a company that has developed a blockchain platform on which there are several initiatives in development. In April 2018, Santander Bank launched One Pay FX, a remittance service based on Ripple platform that allows transfers to several countries reducing the transaction execution time from four days to just one day (Santander, 2018). The same company created a product called xRapid that is being used to send US dollars from the United States to Mexico, where the recipient directly receives Mexican pesos (Ripple, 2018b). The process takes only a few minutes and is significantly cheaper than a traditional remittance operation.

Loans and mortgages. The credit and mortgage process is complex and involves several stakeholders. The required paper work generates inefficiencies and sometimes errors. By making use of blockchain properties, a business network can deliver relevant information in real time to each stakeholder about the status of an asset and its related documents. Each stage in the sale of an asset and a financing transaction can make use of intelligent contracts to enforce the rules of the business and the ownership of the asset can be transferred automatically (PwC, 2016). Additionally, during the process, the payment movement and documentation can be easily tracked and verified, which allows financial institutions to provide added value and security to the parties through technology.

Trade Finance. The trade finance operations require the approval (often manually) of numerous documents. These allow proving that certain goods are in a certain destination and that their transport and load meets specific conditions. The parties involved include customs, port authorities, transporters, sanitary authorities, among others. The complexity lies in the handling and tracking of the documentation that these parties use. A blockchain platform can integrate these parts into a business network in which the documentation is digitally approved and which serves as a single source and real estate for all (Deloitte, n.d.). Insurances can be automatically issued, and claims could be paid according to rules translated into Smart Contracts code. This significantly reduces times and eliminates the need of manual handling of documents (Gupta, 2018).

KYC and identity management. Anti-Money Laundry (AML) rules are becoming stronger and force banks to perform more checking operations to know who their customers are (ACAMS Today, 2018). This creates costs and frictions in financial processes and reduce the pace of business generating a bad experience on the client. Blockchain is presented as an alternative that is currently analyzed by consortiums of financial institutions and seeks its way to the real application (Patel, 2018). Each time a customer opens a bank account, their information is verified, and an encrypted KYC record is stored in a blockchain. The authorities and the financial industry have access to this information and allow KYC verification operations to be carried out quickly while at the same time complying with the AML regulations (KPMG, 2018). Blockchain provides guarantee on the veracity of records, improves efficiency by decreasing verification times and provides greater transparency.

Supply Chain Management

Food industry. Our world constantly demands greater food safety, availability and freshness. When we buy food in a supermarket or restaurant, we trust its origin and safety. However, the difficulty of guaranteeing the origin of products that enter the supply chain and their proper handling across it represents a huge challenge for the food industry. Blockchain makes it possible to create a network involving producers, transporters, distributors and even authorities. Here, the producer registers the products he delivers to the supply chain, the transporters register the transport conditions and the authorities register the controls they have carried out. The information shared allows to eliminate friction and inefficiencies in the chain and provides transparency to the industry and added value to the end user (Deloitte, 2017). Currently, several companies have made successful prototypes in different countries. In a pilot project Walmart used the platform developed by IBM Food Trust and was able to track a shipment of mangoes and obtain information on their origin in a couple of seconds, something that traditionally takes 6 days (Kamath, 2018). Nestlé is also testing a blockchain-based system to track the origin of food used in baby food (Nash, 2018). These two companies are part of a consortium of more than 90 entities that seeks to provide greater transparency and security to the final consumer (Henderson, 2018).

Moreover, authorities can make use of this blockchain solution by tracking down food that has caused security incidents. In June 2018, after months of research, the FDA American agency was able to identify the source of food that caused the hospitalization of 200 people and the death of 5 more (Phillips, 2018). This effort and time can be significantly reduced and allows the authorities to act in a more targeted manner to prevent further impacts in types of events.

Counterfeit prevention. The manufacturing industry has fought tirelessly against the counterfeiting of goods that affects the economy and sometimes puts people's safety at risk. Blockchain allows not only to provide a mechanism to guarantee the origin of a product but also to prove its possession and ownership in an efficient way. Everledger is one of the pioneering examples in providing a mechanism to guarantee the origin of a product (Everledger, 2018). This company allows a digital representation of a diamond to

be recorded on a blockchain-based on its unique physical characteristics. This allows the consumer to ensure that the provenance of a diamond is legal and the industry in general to provide a mechanism to combat the negative effects of the illegal diamond trade.

For its part, Provenance is an organization whose blockchain platform allows large and small producers to connect with transporters and other players in the supply chain (Provenance, 2018). Each member records information about a product that includes not only its origin but also information about its impact on the environment and the working conditions of those who produced it. The end customers can use their mobile phones to scan a product label, get detailed information about the product and make a more informed purchasing decision.

Logistics. Every year several trillion of dollars' worth goods are distributed globally, about 80 percent of them are transported across the ocean (White, 2018). International trade documentation, sanitary controls and monitoring procedures generate high costs and reduce the speed of such distribution. This is largely since participants in the supply chain have generally independent systems that do not communicate efficiently or just do not communicate at all, creating great friction and inefficiencies. A blockchain platform called TradeLens, created under the lead of IBM and Maersk, has been designed as a tool to increase the speed of processing of trade documents in the supply chain from end-to-end (Nærland, et al., 2017). This tool connects exporters, transporters, ports, authorities, administrators and importers in the network that provides visibility throughout the chain and allows them to exchange events related to cargo in real time. In addition, it digitalizes trade documentation and automates its completion while allowing authorities to quickly approve and stamp it at different stages and across different countries and borders.

Process improvements in the supplier network. A proper implementation of smart contracts, to streamline business processes between suppliers among themselves and the OEM could increase productivity, transparency and predictability. To illustrate, how important a well-maintained information flow is between an OEM and its suppliers, one can look back to the year 2017. In May that year, the OEM BMW had to completely shut down its production lines in Munich for several days, due to a missing vehicle part that BMW outsourced to one of its suppliers (Mittelbayrische Zeitung, 2017). The missing steering boxes came as a surprise to BMW and there was not enough time to find replacement parts to mitigate the breakdown. The dependency from suppliers to large automotive OEMs, as their only client, is often emphasized but this example shows how, vice versa, OEMs are dependent on their suppliers as well. In a complex environment with as many suppliers and sub-suppliers as in the automotive industry, it is key to focus on the right aspects to ensure a successful collaboration among all stakeholders.

Blockchain can support here in the areas of information sharing, data storage and transparency. If a business process in the supply chain network is handled decentralized on a blockchain, it enables real time documentation flow and creates trust for all participants, knowing that their documents are updated in real time and the information that is displayed, is correct. In the case of production complications at the supplier's production plant, the OEM can follow the troubleshooting directly and receives the same information as the supplier itself. The OEM does not have to rely on the honesty or the foresight of the

supplier to tell him directly, that there seems to be an issue with the availability of a certain part next month. The transparency of the blockchain can complement communication channels so that the direct communication between participants can focus on the essential issues at hand.

Also, blockchain could improve payment streams between suppliers and OEMs by setting up smart contracts between all parties that, for example, execute payments automatically, once a vehicle part has successfully been delivered and registered as such on the blockchain.

Healthcare

Medical records. In today's systems, medical records are typically stored in cloud-based databases belonging to hospitals and other medical service providers. Because of their importance to people's privacy, administrators spend large sums of money to ensure the security and integrity of such data. Additionally, their access by other hospitals or health care providers is difficult because their systems may store information in different formats and communication is not efficient. Blockchain might provide a solution in which medical records are directly or indirectly stored in a blockchain network involving physicians, hospitals, pharmacies, laboratories, insurance companies and patients themselves. Patients would have a full control over their records and give consent for access and modification, and hospitals and other providers would have a single place where information is always updated and available efficiently. Estonia has developed this concept on a national blockchain platform that stores the e-Health records of its citizens (e-Estonia, 2018). It allows physicians to easily access patient records in real time while recording each access to ensure patient safety. In an emergency, any service can access critical information such as blood type, allergies, recent treatments or pregnancy. Patients can access their records through their cell phone as well as manage the records of children for which they are responsible or individuals who have authorized their access.

Pharma logistics. The use of blockchain mentioned in the logistics industry can be extended to the drug supply chain. A blockchain platform that integrates suppliers, logistic operators, wholesalers and distributors guarantees the provenance of a product. The authenticity of each product can be tracked and verified at every stage of the supply chain. Additionally, with the use of IoT technology it is possible to know the transport conditions and in case a medicine breaks its cold chain or is subjected to inadequate physical conditions, it can be returned immediately for proper handling. FarmaTrust (FarmaTrust, 2018) and MediLedger (MediLedger, 2018) are two examples of how blockchain is used to improve the pharmaceutical industry. These solutions contribute to reducing the counterfeit drug problem that causes the death of tens of thousands of people each year. In addition to providing patient safety, these applications can significantly reduce costs for reprocessing, re-transportation and counterfeit losses, which in turn can reduce medicine prices in the marketplace.

Efficient management systems. Payers and providers in a network of medical services face great challenges related to the efficient handling of claims. Companies must provide significant amounts of resources expressed in time and manpower for reconciliations and payments. A private blockchain network integrates these actors and serves as a single, true source of real-time information about the filing, submission and status of a claim. With millions of transactions per day, a health care network can optimize its resources, streamline payments, avoid errors, and improve the overall settlement workflow. This not only represents significant savings to the network, but also improves workflow and service provider satisfaction by reducing the time and effort to receive payments. Change Healthcare has developed a solution that applies these principles and promises to provide a mechanism to streamline the interaction between hospitals, physicians and payers (Change Healthcare, 2018).

General Impact on Economy

As seen, blockchain uses extend across multiple industries and sectors. Its potential to change business models and introduce significant transformations in industries, organizations and governments suggests an impact on the global economy. Bitcoin and the thousands of cryptocurrencies that have emerged in recent years represent one of the greatest forces of impact on the economy of this technology in its initial stage. According to the World Economic Forum (Sept. 2015), there are expectations of at least 10 percent of the global GDP being stored on blockchain platforms by 2025. The global economy is connected in a complex way like never before and depends in a very significant proportion on the US dollar, considered the world's reserve currency serving as the anchor currency for more than 60 percent of all countries (World Economic Forum, 2017). This centralizes great power in the American government and economy, and it is precisely this centralization that cryptocurrencies could disrupt or significantly transform. As the adoption of electronic payment methods based on blockchain grows, the dynamics of international trade, foreign relations and diplomacy might change significantly.

However, its impact may not be limited to the way we transfer monetary value on a global scale. Blockchain is a technology that paves the way for the creation of other technologies that allow the transfer of value in different ways through new models of trust in common transactions.

Through this technology, value creators such as artists, composers and designers could transfer this value to their clients or consumers directly or simply with fewer intermediaries. This technology would make it possible to track and control the reproduction of a work, royalties and advertising revenues, all on a consumption basis. In the same way that the music industry went from selling records to selling songs, now it will be possible to bill customers by time of reproduction or number of plays with more efficient payment systems as a tool. The control of intellectual property can be executed on blockchain platforms that protect producers and allow a fairer trade of their works. In

general, the media industry may be disrupted through new micropayment-based pricing models, bigger limitations to piracy and the bypassing of content aggregators, platform providers and royalty collectors (Deloitte, 2017).

On the other hand, digitization has allowed the emergence of new business and consumer models such as the sharing economy. This has enabled significant growth and it is estimated that the revenues from the sector will reach \$40.2 billion in 2022, up from \$18.6 billion in 2017 (Juniper Research, 2017). Despite bringing economic, social, environmental and practical benefits, asset management is centralized and business models are not fully equitable in the distribution of the value generated. Today, this economic model has created giants like Uber and AirBnB that accumulate value in an inequitable way and are subject to attacks that compromise the privacy and security of their users (Williamson, 2018). Blockchain allows the inclusion of self-regulating and self-controlling elements that give users the opportunity to manage and govern the platforms used and ensure a more equitable distribution of value. Through the use of blockchain-based platforms users can not only use the services but also obtain additional benefits from participating in the management and control of the network (Filippi, 2017). Additionally, blockchain can also include micro-payment mechanisms, increasing the level of security and privacy for users thus making the platforms more efficient and independent. New applications based on blockchain are constantly being created that allow the generation of value in ways that did not exist until now, increasing the inclusion of ordinary people in economic activities and contributing to a more inclusive economy (Tapscott & Tapscott, 2016).

But how global is our economy? According to the International Monetary Fund, by 2016, nearly 2 billion people had no access to a bank account (Maino, 2016). This condition excludes this population from the global economy and for this reason the financial system is looking for solutions among which mobile banking is one of the greatest advances. However, it might be possible to trigger even greater improvement by combining mobile telephony with blockchain technology. Direct international transfers with lower costs, mechanisms to prevent fraud that ease the opening of bank accounts, identity certification systems and ownership of property are among the possibilities that these technologies can offer to the currently unbanked population (BBVA, 2018).

Despite the above, it is still difficult to establish whether blockchain will have positive impacts on other global elements such as the reduction of inequity (Novak, 2018). Bitcoin and other blockchain-based payment mechanisms are expected to enable people excluded from the financial market to become part of the economy. However, it has been shown that about 97 percent of Bitcoins are concentrated in only 4 percent of addresses (Brennan, et al., 2018) and there are many non-technical factors on which the massive adoption of technology for fair and economically beneficial purposes depends.

General Economic Discussion on Blockchain

Blockchains may have the power to radically alter the way in which socio-economic interaction is coordinated by decentralizing different processes related to public registries

(Berg, et al., 2018). Governments are responsible for centralizing the sets of rules that regulate our socio-economic interactions. However, governments are only one way to keep these records. Blockchain is presented as an alternative form that does not require giving control to a central authority (Markey-Towler, 2018). Examples include decentralized voting systems that can provide transparency and auditability (Moura & Gomes, 2017), educational record keeping and reputation systems (Sharples & Domingue, 2017) and different forms of e-Government services through decentralized applications (Diallo, et al., 2018). Blockchain allows the promotion, keeping and verification of institutional structures and keep a public record of interactions through them. This represents a potential for transforming how we conduct market exchange (MacDonald, et al., 2016), the way we use contracts and collaborate (Davidson, et al., 2016) and the way we govern ourselves in the context of established rules (Allen, et al., 2017). According to this scenario, central authorities may in the future tend to move from a central control role to being providers of platforms and governance for decentralized services (Berryhill, et al., 2018). Governments then have two ways of approaching blockchain technology. The first as an innovative general-purpose technology that goes through stages in its adoption to the economy as other technologies such as computers or the Internet have. This approach is widely discussed and although not incorrect it could be considered misleading (Davidson, et al., 2016). Taking this approach would further measure the importance of blockchain technology in terms of its ability to deliver efficiency and productivity. On the other hand, a second approach focuses on seeing blockchain technology as an institutional technology (Davidson, et al., 2018). This approach would allow blockchain to be approached as a new form of economic coordination in which the importance of its adoption is focused on the way it will compete with companies, markets and economies as an institutional alternative to coordinate the economic actions of groups of people. From this perspective, Blockchain is not a technology but a new type of economy that allows the generation of "autonomous organizations" with constitutional, market and government properties. This represents for governments in any case a challenge in the evolution of society (Markey-Towler, 2018).

Challenges

Despite the advantages that blockchain technology can offer, there are challenges to its development and widespread adoption. According to Deloitte, as the blockchain ecosystem evolves and greater applications and uses are adopted, organizations will face new, complex and potentially controversial challenges. Some of the challenges initially identified include awareness and understanding of technology, ecosystem organization, efficiency, regulation, governance, security and privacy (Deloitte, 2016).

A study conducted by the Cambridge Centre for Alternative Finance at the University of Cambridge assessed the challenges of distributed ledger technology adoption among more than 200 different stakeholders.

Lowest average score  Highest average score

1: Strongly agree 2: Somewhat agree 3: Neither agree nor disagree 4: Somewhat disagree 5: Strongly disagree

CHALLENGES TO BROAD DLT ADOPTION	WEIGHTED AVERAGE	INFRASTRUCTURE PROVIDERS	APPLICATION DEVELOPERS	OPERATORS
Legal risks/regulatory framework	1.97	2.25	1.60	1.64
Confidentiality issues	2.09	2.05	2.20	2.10
Reluctance to change established business processes	2.17	2.47	2.00	1.73
Immature technology	2.28	1.85	3.20	2.64
Difficulty of building business network	2.44	2.45	2.20	2.55
Potential issues with data protection laws	2.60	2.85	2.80	2.00
Scalability/performance concerns	2.81	2.70	2.80	3.00
Reluctance to give up some control	2.88	3.05	2.60	2.70
Security concerns	2.91	2.95	2.80	2.89
Unknown costs/benefits	3.08	3.14	3.60	2.70
Lack of suitable use/business case	4.00	4.10	4.00	3.82

Note: The lower the score, the more important the challenge is considered (1: very significant challenge; 5: no challenge at all).

Figure 6: Challenges for broad adoption of DLT (Hileman & Rauchs, 2017)

From a legal perspective, the ease of conducting cross-border transactions poses a particular challenge in terms of the regulations that can be applied. In a decentralized application whose nodes may be in different countries and are part of the processing, it is difficult to determine which set of rules must be applied. Technically, each transaction could be in the jurisdiction in which each node is located. This would imply that the application should be compliant with a large number of regulations and regimes (McKinlay, et al., 2018). Similarly, regulations relating to the processing of personal data, such as the GDPR in the European Union, represent a constraint to the creation of solutions in production environments.

Privacy and confidentiality are central issues in a blockchain solution and can slow down the deployment of applications. Many blockchain applications unquestionably require linking transactions to known identities raising the requirements for data privacy and

security. Data encryption in the ledger as well as pseudonymization are the most commonly used methods according to the study. In fact, these technologies represent work skills with high demand in the labor market and with growth that has increased disproportionately between 2017 and 2018 (Kelley, 2017) (Stein, 2018) (Lee, 2018). As demand significantly outstrips supply, the development and rapid adoption of blockchain solutions can find here an additional constraint.

Another limiting factor is the resistance of some organizations to change in the established business processes. Since blockchain technology makes more sense in multi-stakeholder applications, whether individuals or organizations, a common understanding is essential. Consortia wishing to implement blockchain solutions must establish governance protocols and standardize formats, procedures and interfaces. Legacy Systems may vary from one organization to another in a consortium, meaning that the integration of the blockchain solution with such systems requires a significant amount of time, resources and human expertise (Lielacher, 2018).

In permissionless public blockchains, the immutability and the automation provided by Smart Contracts are aspects that offer advantages that other technologies do not. However, when a Smart Contract is "installed" on the network it cannot be modified without compromising the integrity of the data in the ledger and by using its vulnerabilities it is possible to generate attacks (Prinz & Schulze, 2017). Liability in the event of a safety or design fault in a Smart Contract can make a transaction to be erroneous and completely irreversible. In this case, accountability cannot be attributed to a single organization or easily intervened by an authority.

From a technical point of view, the scalability of blockchain-based systems is one of the main challenges of this technology. The ability to connect an increasing number of users, the number of transactions and latency are of major importance when thinking about global solutions. This is particularly important in the field of cryptocurrencies and digital payment mechanisms. The scalability problems of some solutions raise questions about whether these networks can be scaled to mass adoption (Arizona State University, 2018).

According to the industry, additional challenges in the adoption of blockchain solutions arise. For example, in the case of the financial industry, the adoption of cryptocurrencies as widely accepted payment mechanisms is still very limited. According to Carlos Torres, CEO of BBVA, the "volatility of underlying cryptocurrencies" and frictions with authorities and financial regulators do not allow its widespread use (Berman, 2018). Some sectors of the financial industry demonstrate very conservative positions and openly oppose to the use of cryptocurrencies. As an example, Jamie Dimon, president of JPMorgan, called Bitcoin a "fraud" and despite softening his position a few months later, he considers it not a topic of interest (Samson, 2018). Despite this, in recent years the financial industry has shown a more flexible position and is investing heavily in research into technology and its uses in banking. An Accenture study assures that 9 out of 10 executives interviewed say their bank is currently exploring the use of blockchain (Accenture, 2018).

In the case of the healthcare industry, the challenges are more focused on the network security and privacy. As the banking industry strengthens its security systems, attackers are moving to less protected industries, such as healthcare (Scott, 2018). Failures in their

systems have consequences that go beyond the loss of money and may include, for example, the theft of medical records. This in turn facilitates the theft of identities that are traded on the black market. Blockchain solutions in this sector have the challenge not only to ensure the protection of information but also to do so at levels comparable to those in the financial services industry.

B INDUSTRY CLUSTER ANALYSIS

The structure of this chapter is as follows. First, we give a general introduction into the concept of clusters and its relevance in today's economy. This is supposed to underline why policymakers as well as entrepreneurs should care about clusters. Second, a look at cluster studies already performed in Denmark follows. Third, we present a small analysis on the public visibility of the topic in Denmark. Fourth, an industry cluster analysis that provides an overview of the Danish blockchain cluster follows. A special focus of this exploration is put on the supply chain industry blockchain actors. Overall, this section provides an overview and insight into the Danish industry clusters, specifically the ones regarding blockchain and supply chain.

Fundamentals of Industry Clusters

The Concept of Clusters

The first studies about agglomerations of economic activities can be traced back to the early 20th century, when the English economist Alfred Marshall studied "concentrations of specialized industries in particular localities" which he called industrial districts (Marshall, 1920). Marshall studied industrial districts in Europe and associated geographical grouping of economic activities with physical conditions such as raw material availability or climatic characteristics (Abdin, 2018). The limitations in communications and transportation that existed before the middle of the 20th century meant that companies tended to be located close to where their input resources were and therefore industries often developed organically in clusters around these resources. Some examples of these developments in North America are the textile industries in New England, the automotive industry in Detroit and the steel industry in Pittsburgh. Thus, clusters have been a subject of interest and study by economists for over a century (National Research Council, 2012). At the end of the 20th century, Michel Porter introduced a more modern conception of clusters as a group of interconnected companies and associated institutions, linked by commonalities and complementarities within a geographical area. Later on, he defined clusters as "geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, trade associations) in a particular field that compete but also cooperate" (Porter, 2000). His

ongoing work has laid the groundwork for further studies on how clusters are formed, their characteristics, and how they affect the economic competitiveness of regions.

The organizations that form part of a cluster are usually of different nature and include not only producers, suppliers of production goods and service providers but also other companies in industries related by skills, technology or common inputs. Clusters are also characterized by including educational and vocational training institutions, governments, research institutions and trade associations (Porter, 2014). The organizations that conform a cluster relate to each other through three interconnecting elements: geographical location, functional relationships and the presence of institutional linkages. This means that the organizations in a cluster are related among others, through knowledge, skills, supply, demand, technology and inputs (Delgado, et al., 2016).

“A cluster allows each member to benefit as if it had greater scale or as if it had joined with others formally—without requiring it to sacrifice its flexibility” (Porter, 1998).

The benefits of grouping institutions into clusters have been studied, especially, through case studies in particular regional clusters (Clark, et al., 2018). Clusters improve the competitiveness of a nation or region, understanding this as the capacity of industries to become embedded in a deep network that supports concentrations of companies, institutions, customers and complementarities (Smith, 2003). On the one hand, clusters allow member companies to operate with greater productivity by improving the supply of inputs, skills, access to specialized information, technology and specialized institutions. For example, clusters tend to attract the attention of experienced and skilled workers and provide better access to suppliers. In addition, clusters drive innovation and stimulate the creation of new businesses by providing conditions of access to venture capital and investment bankers (Porter, 1998). The information about market and technical opportunities flows at higher speeds within clusters. This reduces invention costs and facilitates large scale growth (Bresnahan & Gambardella, 2004).

Clusters are an important element in competition and competitive strategies in the context of a global economy and represent a way of thinking about the economy of regions and nations (Porter, 2000). In addition to presenting benefits to member organizations, clusters provide practical value for policymakers and they have become a dominant element in public policy around the world to promote regional competitiveness, innovation and growth (Fornahl & Hassink, 2017). In the United States, the support of the national government and state governments for the development of clusters has been reflected in higher productivity, greater innovation, better salaries and more satisfactory entrepreneurship for the regions than those possible without the coordinated work of a cluster. Thus, the promotion of clusters as part of the economic development of regions is seen by policymakers more as a paradigm than as simple program for economic improvement (Muro & Katz, 2010).

Finally, it is necessary to highlight that clusters are not a guarantee of success. Like any system, they are also subject to periods of decline and total failure. The reasons for the demise of a cluster include a varied spectrum of factors such as the availability of skilled workers and the raise of resource costs. An example is the Cambridge cluster, which witnessed different declining factors such as loss of employment, retirement of key firms,

and reduction in the number of incoming companies over different time periods (Stam & Garnsey, 2009). Some of the reasons found for failure in cluster initiatives around the world include relying too much on top-down-approaches, the wrong motivation for creating the clusters (for example to create prestige for policymakers instead of the development of economy), incompetence and placing actor's interests above public interests (Baily & Montalbano, 2018).

The Importance of Location in a Globalized Economy

In recent decades, the ease of communication and transport has promoted the outsourcing of activities, the relocation of many companies and the geographical division of work units. Firms now do not necessarily need to be close to specific markets to participate in them. Instead, they can use modern telecommunication networks as well as sophisticated supply chains to reach markets and have multiple means to access inputs like capital, technology and skills. This trend may suggest that the importance of geographical agglomerations tends to decrease as economic activities become more open and decentralized. However, despite this it is observed that the location of certain industries and economic activities is still at least as relevant as before, if not of increased importance – especially in developed nations (Delgado, et al., 2016) (Enright & Roberts, 2001). This has created a paradox that in turn has aroused a research interest in economics. The new economic geography, formerly considered as part of the study of geography and regions, and now with a greater focus towards to the study of economics, discusses in depth how economic systems determine where to produce. This field of study investigates the importance of distribution and spatial orientation of economic activity (Smith, 2012). For its part, Porter found a direct relationship between economic development and the microeconomic business environment, especially from clusters. He concluded that the co-location of firms, suppliers and other institutions generates pressures between them that benefit productivity and the capacity to innovate (Porter, 2000).

Although proximity itself is not considered a limiting condition for the development of a cluster (Zimmermann & Rychen, 2008), it is evident that historically clusters have been formed from location-related conditions (Institute of Management Services, 2000). Location and proximity play an increasingly important role in economic activities, which is why clusters as productive agglomerations with geographical delimitation are integral elements of current public policy for increasing productivity and competitiveness.

Service-oriented Clusters

Although historically, industrial clusters have been more numerous, services have taken great relevance in the world economy, motivating the creation of prominent service-oriented clusters. Unlike industrial clusters that traditionally have an approach that seeks to increase productivity and efficiency through economies of scale and scope, service clusters present a focus on consumption and user-perceived value with an emphasis on service and

innovation (Hsieh, et al., 2012). In addition, physical assets do not have equal relevance in service clusters, so vertical integration in the supply chain is not determinant. The orientation of service clusters focuses with greater priority on the relationship between firms connected at the horizontal level (Hsieh & Li, 2011).

Following the taxonomy for services proposed by (Miozzo & Soete, 2001), high-tech oriented clusters such as the Silicon Valley might be considered as service-oriented clusters. With the advent and growth of information technologies, this type of clusters has played an important role as a fuel for economies. The United States was host to a significant economic development during the 1980s and 1990s largely driven by growth in information technology related industries within the context of regional clusters. Nevertheless, the success of high-tech clusters may be associated with factors that are still not fully researched and include but are not limited to the introduction of new technologies like the integrated circuit or the internet (Bresnahan & Gambardella, 2004).

Examples of High-tech Clusters

Currently many countries have policies and strategies for cluster development as a mechanism to boost their economies. In 2009 alone, 26 of the 31 nations of the European Union had national cluster development programs (National Research Council, 2012). Currently, some of the clusters focused on the development of high-tech industries most relevant to the economies of their countries include the Silicon Valley, Route 128 (USA), Silicon Wadi (Israel), Silicon Fen (England), Shenzhen Hi-Tech Industrial Park (China), Hsinchu Science Park (Taiwan), Canada's technology triangle, GIANT – Grenoble (France), Isaar Valley (Germany), Silicon Docks (Ireland) and Science Park Amsterdam.

The reasons for the success of different high-tech clusters around the world depend on different factors. The cooperation between the members of the clusters and the local leadership appear to be essential. But while the start-up economic support of governments may be essential, during the development phases private funding needs to be attracted by the clusters themselves. Moreover, skilled workers have played a central role in nascent technology clusters and the support of governments in the role of customers of the technology is also mentioned. Finally, a long-term view is required, and policymakers need patience to see the positive effects in the economic growth that clusters bring (Baily & Montalbano, 2018).

Clusters in the European Union

From the EU Smart Guide to Cluster Policy: "Europe is home to some 2,500 strong clusters, i.e. statistically defined regional concentrations of related traded industries that achieve above average performance for employees, firms, and regions. Cluster effects become visible when the presence of related industries in a specific location reaches critical mass. Roughly 45 percent of all employment in traded industries is in strong clusters. Employees

in strong clusters earn on average 11 percent higher wages than their colleagues in the same industries but located outside of clusters. This reflects the higher productivity that companies can achieve in clusters. Strong clusters have reported job growth of 0.2 percent annually in the post-crisis period (2008-2014), while traded industries outside of strong clusters have lost 1.7 percent on average. Research in the US has shown that new business formation is higher in strong clusters, and that new firms are more likely to succeed and grow if located in strong clusters. Clusters are in most cases not 'created': they emerge, because different locations provide different types of opportunities for specific companies to invest, succeed, and grow. Clusters are the result of a cumulative process, where the success of one company paves the way for others to follow. Such processes take a long time and are inherently unpredictable. Cluster evolution is a natural process, but it is not automatically a successful one. In most cases, success depends on creating specific qualities of a business environment that give a location a unique and lasting advantage. By helping to create these qualities, governments can have a significant influence on the emergence and growth of a cluster.

What Clusters are and what they are not

Thomas Krogh, CEO of innovation hub CPHFINTECH emphasizes "There is much more to creating a cluster than just forming a network or a hub. It is doubtful if much of what is called "Clusters" today really are clusters with the vibrant energy that indicates – they may be useful networks or hubs. CPHFINTECH is a fine example. It is today one of the leading Fintech hubs in the global financial services industry and there are certainly aspects of a cluster, but it takes time to grow one".

One key issue is the lack of understanding from public authorities and universities of what it takes to be entrepreneurial. They jump to implementation mode much too quickly without appreciating the early phases of business research and development.

Clusters are not synonymous with cluster initiatives. While the former refers to the concept that describes the real economic phenomenon of concentrations of economic activities such as Silicon Valley or the City, London's financial district, the latter describes an initiative or political effort to create, maintain, or upgrade an economic stronghold or cluster.

Clusters are not synonymous with specialization. While clusters reflect the specialization of locations in specific economic activities, they capture two important additional aspects. First, clusters reflect specialization in groups of related industries, not just one narrow activity. Much of the dynamism of clusters derives from these 'economies of scope' rather than static 'economies of scale'.

Other Cluster Studies Performed in Denmark

The official Denmark (e.g., legal system and monetary support) has looked into stimulated clusters (“klynger” in Danish) for the past 30 years at three governance levels: State - Regions (there are five) and counties/municipalities (98 after a series of reforms in the 90’es). Each has promoted “klynger” to increase direct and indirect benefits from these resulting in 40- 60 “klynger” in Denmark without a common approach and interpretation.

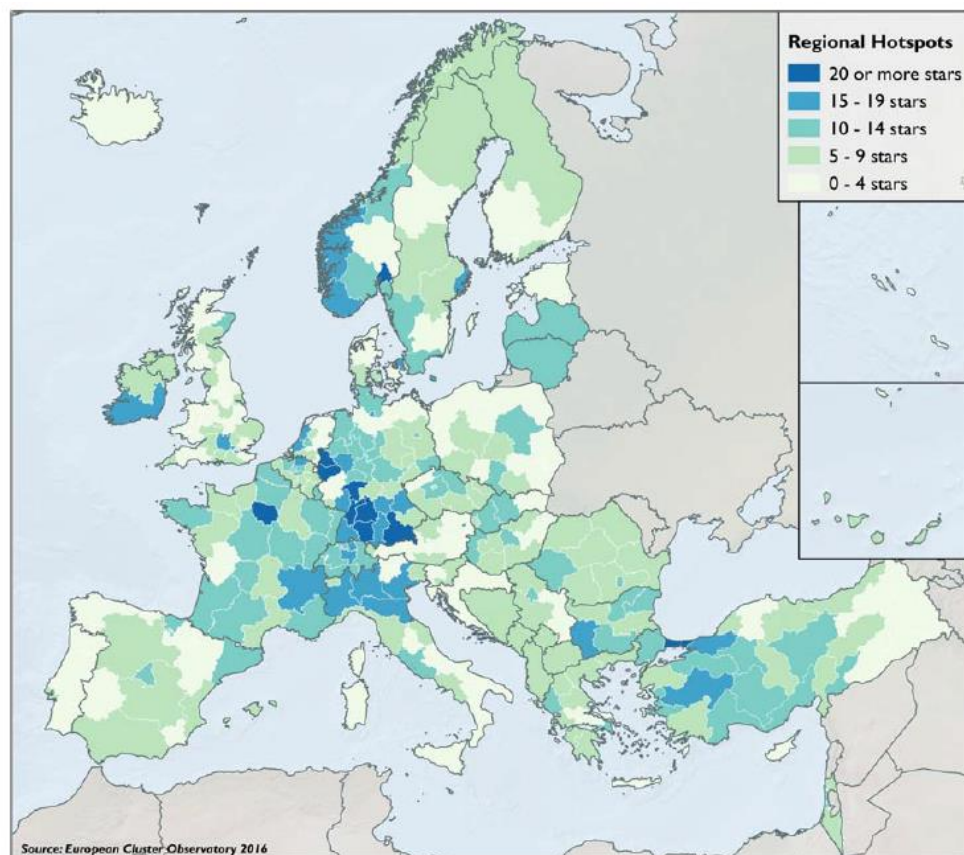


Figure 7: European regional hotspots of cross-sectoral, emerging industry clusters (Ketels & Protsiv, 2016)

To increase effectiveness and improve results the law has been changed, from January 1st, 2019. Now, there is a strong centralized approach on “klynger” directly from the Erhvervsministeriet, the Ministry of Industry, Business and Financial Affairs. The intention is to consolidate the number to 10-12 “klynger” with a more harmonized approach in establishing and evaluating and attempt to strengthen these. The law should be implemented at the end of the third quarter in 2019 with radical changes to executing and financial and resource supporting structure. It is part of an overall drive to increase effectiveness, reducing overhead and boost corporate performance.

If one compares with the EU in general, Denmark is way behind in effective clusters; “hot spots”, biopharmaceuticals in the greater Copenhagen area being the only exception, please

refer to below illustration from European Cluster Panorama 2016 from European Cluster Observatory (Ketels & Protsiv, 2016) (European Commission, 2019).

Recently, the Danish government established Cluster Excellence Denmark (Cluster Excellence Denmark, 2019) as the national support service for clusters and innovative networks in Denmark. The aim of the support function is to professionalize and secure competence development for clusters and networks in areas such as management, internationalization and other external relations. This work is closely coordinated with the national strategy for Denmark's cluster policy.

In 2017, 16.545 companies participated in the activities in Danish clusters. 4625 companies developed new ideas, which may lead to innovation. 5804 companies were introduced to new competences and tools, which significantly improves their capability to innovate. 2395 companies developed new products, services or processes as a result of cooperating with one of the Danish clusters (Cluster Excellence Denmark, 2019).

With that, in the following we review other cluster studies that were conducted in Denmark in the last decades. (Drejer, et al., 1997) provides an overview of cluster studies that were conducted in the 1980's and 1990's, there have also been some studies that have more focused cluster study observation in Denmark. One example is one conducted by (Engelstoft, et al., 2005) where they observed specifically two types of Danish industrial clusters; the textile and clothing cluster and the wood and furniture cluster in the Western Jutland. They compared their cluster analysis to a similar one that was conducted in Italy and built off of previously used theoretical concepts of industrial and economic development. Another study included Denmark as one of the 10 countries selected in a Porter Studies of competitive advantages, where they analyzed ten or more industries of each country and applied his Diamond Concept (Drejer, et al., 1997). More recent studies published by, (Nielsen, et al., 2016).

The study conducted by (Engelstoft, et al., 2005) used a qualitative approach based on case studies and then two quantitative approaches that observes knowledge spill overs in regards to economic outcomes (e.g. employment levels and growth, income growth, and productivity) and a spatial agglomeration, which regards to localization and urbanization economies. The analysis is based on a regional economic database that was provided by the Local Government Research Institute (AFK) in Copenhagen Denmark. The time period was from 1970-1994. While the clusters identified were not identical to the sectors, the authors decided that they were close enough for analysis. As for their results, they reconfirm the findings of (Martin & Sunley, 2001), that a "cluster (analysis) is a chaotic and heterogeneous concept" (Engelstoft, et al., 2005). They find limited evidence to confirm the existence of the two observed industrial clusters, however suggest that the likelihood would be greater of proving this existence in high-tech sectors and urbanization of economies (Engelstoft, et al., 2005).

Further, (Drejer, et al., 1997) point out that while cluster studies can be a resource of observation of the change in economies, that it is important to state the obvious that theoretically based studies are not always easily combined with policy making. (Drejer, et al., 1997) provide an overview of cluster studies over Denmark in the 1980's and 1990's. They take initiative in observing the analytical methods and measurements used in the

cluster studies that were conducted in Denmark. Cluster Studies in Denmark previously focused on identifying production clusters, when as time progresses the importance of innovative clusters have come into focus (Drejer, et al., 1997). The authors identify that within this time period that the cluster analysis in Denmark can be considered into two groups of studies: the industrial complexes and the micro-founded studies. The industrial complexes that were studied were the following; the agro-industrial complex, the textile complex, the environmental complex, and the office machinery complex, which related to the fore mentioned production focus. The other group of studies were micro-based cluster studies that concentrated on the linkage between the distributions of knowledge within an innovation system (Drejer, et al., 1997).

Figure 8 summarizes some of the fundamental cluster study findings in the last decades that were presented in (Drejer, et al., 1997).

Source	Concepts explored	Outcomes
(Porter, 1990)	Using a 'diamond concept' the input-output types of relations between industries, while also including competitive environment and demand conditions of clusters	Porter's diamond concept
(Porter, 2001)	Geographical proximity variable of Porter's diamond is more so included	Lack of clarity of the relationship between Porter's diamond and geographical components
(Markusen, 1996)	Explores the importance of including different governance structures of cluster typology and external orientation	Impact of varying governance of clusters in the analysis and including external orientations of firms and their impact on the cluster analysis location
(Gordon & McCann, 2000)	Observes a 3-fold typology of clusters 1.) Industrial complex model; 2.) a model of pure agglomeration and 3.) a social network model	A structured methodology of observing linkages of industries on multiple levels

Figure 8: Summary of some foundational cluster studies

In the last decades, there has been an increasing number of voices that criticize the validity of conclusions that have been drawn from cluster studies in Denmark. Economists increasingly focus on the importance of distance measures such as spatial or cultural proximity in economic activities as a pillar of economic growth (Engelstoft, et al., 2005). As for cluster studies that are focused on one particular sector, the working paper by (Hansen

& Clasen, 2010) applies a cluster analysis to learn which dynamics and economics impacts can be made in regards to the maritime sector for various economies. (Hansen & Clasen, 2010) took into consideration how clusters and the importance of clusters effect maritime activities in various European economies. They observe that clusters do play a significant role as regions with higher levels of clustering tend to have higher incomes and employment levels. In particular to maritime clusters, they recognize that they are particularly influential for many European countries as they account for a good part of percentages of total GDP and employment of those nations (Hansen & Clasen, 2010). One of their results that they discovered by conducting a cluster study was that they observed how maritime activities do have a significant impact on economic activities and employment inland and not just at sea. They also generated insights what determines change and growth in the maritime sector and identified “shipping ports” and “offshore” as main drivers (Hansen & Clasen, 2010).

Another Cluster study by (European cluster Mapping Project, 2008) conducted for Southern Denmark analyzed the dynamics in the food industry. They highlight the importance of the food industry in Denmark as it was responsible for one third of Danish exports in 2008. They used a cluster study to analyze the importance of geographical location, especially if it is near other major European markets, and the linkages or cooperation with other industries in its natural value chain. In that study, the researchers focused on how to improve the connectedness of companies in the market and tried to identify new areas, markets, or companies that could eventually lead a cluster (European cluster Mapping Project, 2008).

Overall, this section has observed how the importance of cluster analysis has been recognized in Denmark among various industries. Understanding and observing cluster studies can help to recognize new innovation opportunities, strong network ties that could be utilized of companies, or various effects of industries within a country, all of which are of importance for growth and development.

While it is too early to say which will be the driving forces for a blockchain industry cluster in Denmark, there are several startups and more established companies in the greater Copenhagen region that may indicate the emergence of a blockchain industry cluster. Companies such as Coinify, MakerDAO, Openledger, or Chainalysis have a strong presence in the Danish blockchain industry, while being competitive on an international level.

Public Visibility of Blockchain Technologies in Denmark

As first step towards the cluster analysis, this chapter will give an overview on the current public interest on blockchain and related technologies and topics in the Danish public. To do this, we performed at first a Google Trends Analysis of blockchain-related search queries. Second, we give an overview of Danish blockchain initiatives in the public and private sector.

Google Trends Analysis

Google Trends enables us to analyze the volume of Google queries by its geographic location over time. It can therefore allow us to track how the interest in blockchain and related technologies and topics has been developing in Denmark – if we regard Google search queries as proxy for this interest.

We identified the following keywords as relevant for our purposes:

- Blockchain
- Bitcoin
- Crypto / Krypto
- Ethereum
- Hyperledger
- Distributed-Ledger-Technology (dropped for insignificant results)

Search terms such as “token” were also used in other contexts and thus would not yield meaningful results. As the Bitcoin blockchain whitepaper by Satoshi Nakamoto was published in late 2008, the time period for this analysis starts in 2009.

Figure 9 illustrates the whole time period and directly compares the interest in the different topics. Public interest is clearly dominated by Bitcoin, which has its peak of interest in December 2017, overshadowing all other topics by far. Note that this is also the point of reference for all other data points. For Ethereum the interest was also the highest in December 2017, but there were about 10 times as many searches for Bitcoin (indexed value of 100 in December 2017) as for Ethereum (indexed value of 10 in December 2017).

What the figure shows as well is that the interest follows the price of Bitcoin in US dollar quite closely. The price is represented in the chart as an index between 0 for the lowest price (also the first price data that could be obtained in March 2012) of \$4.9 per Bitcoin and 100 for the highest price in the time frame of \$13,800 per Bitcoin (average monthly prices).

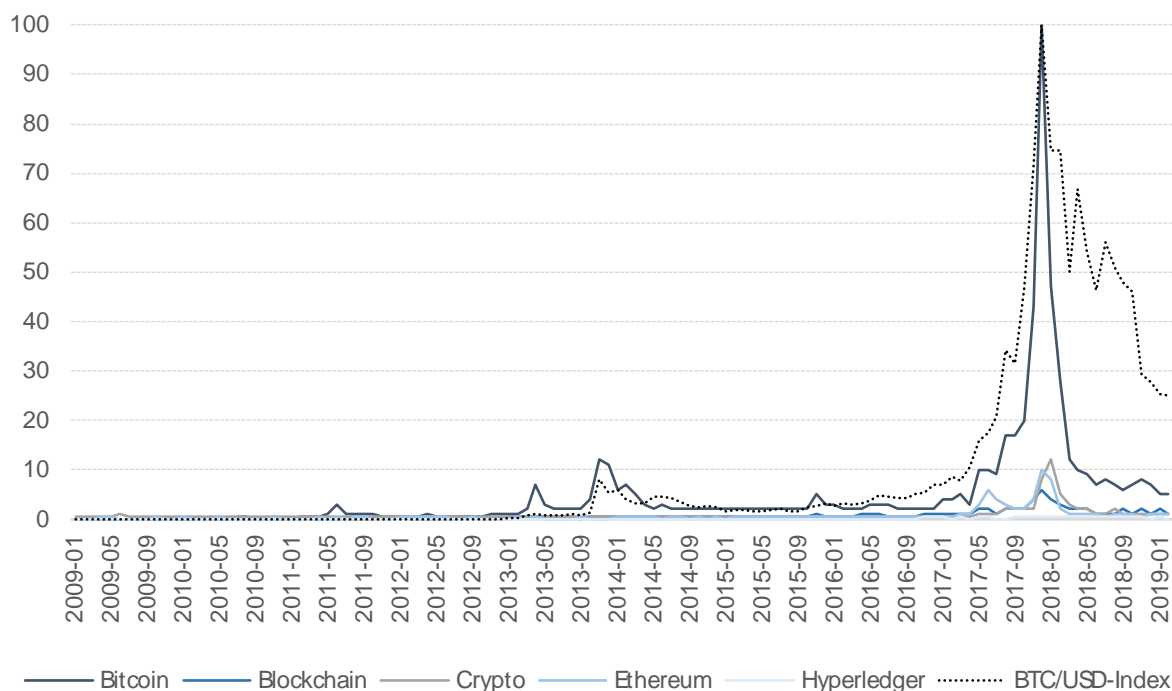


Figure 9: Google Trends data for blockchain and related terms in Denmark from 2009 to 2019

It can be seen that in the first eight years, there was barely any movement, except for a few spikes in 2013 and early 2014 that follow the Bitcoin price.

Ten years are a long period for the analysis, and the first years show barely any activity. Therefore, we limit the time frame for the following analysis to 2017 – early 2019 (Figure 10).

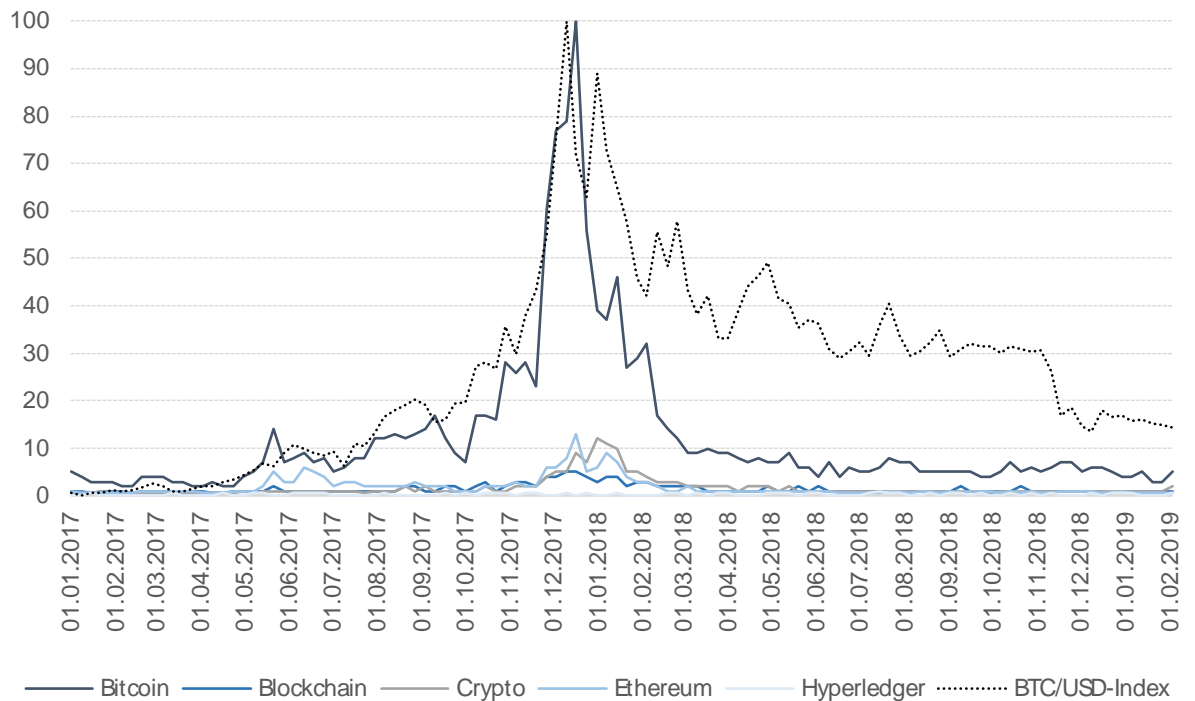


Figure 10: Google Trends data for blockchain and related terms in Denmark from 2017 to 2019

As Bitcoin is so dominant, we removed it for Figure 11 to allow for a closer look at the other topics. Again, it is apparent that the interest in the topic Ethereum as well as blockchain and other related topics follows the price of Bitcoin in USD. Adding other crypto-tokens such as Ripple or Litecoin does not change the picture at all, which is the reason why those were omitted here.

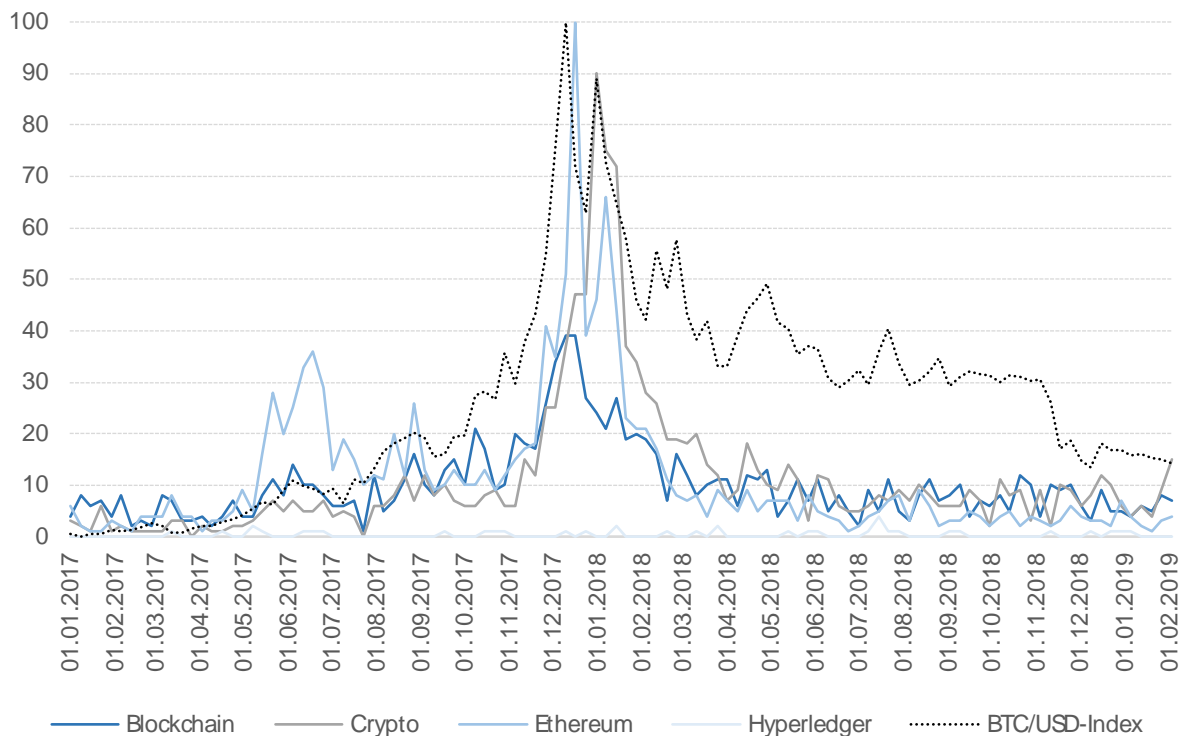


Figure 11: Google Trends data for blockchain and related terms (excluding Bitcoin) in Denmark from 2017 to 2019

The general public’s interest in blockchain – as it can be measured through a Google Trends analysis – seems to be driven by the price for Bitcoin (or cryptocurrencies in general) to such a large extent that it overshadows other potential factors of influence. Such factors could have been news items about organizations starting blockchain projects or governments picking up the topic. Our analysis shows that these other factors cannot outweigh the influence of the price of cryptocurrencies on the public interest on the topic.

Finally, we wanted to see if there are any significant differences between the Danish interest in the topic and the international one. Therefore, we compared the Danish Google Trends data with worldwide data and data from the US. Figure 12 exemplary shows this comparison for Ethereum. Second to Bitcoin, it has been the most popular search term. Results are similar for the other search terms.

The search terms aggregated on a global level are very similar to the distribution found in the US. The Danish data follows the same pattern, but the values are usually a bit lower. However, as the results for this figure are scaled individually between 0 and 100 for each of the region, one cannot conclude from this data that the relative interest in Denmark was lower than in the other regions of the world.

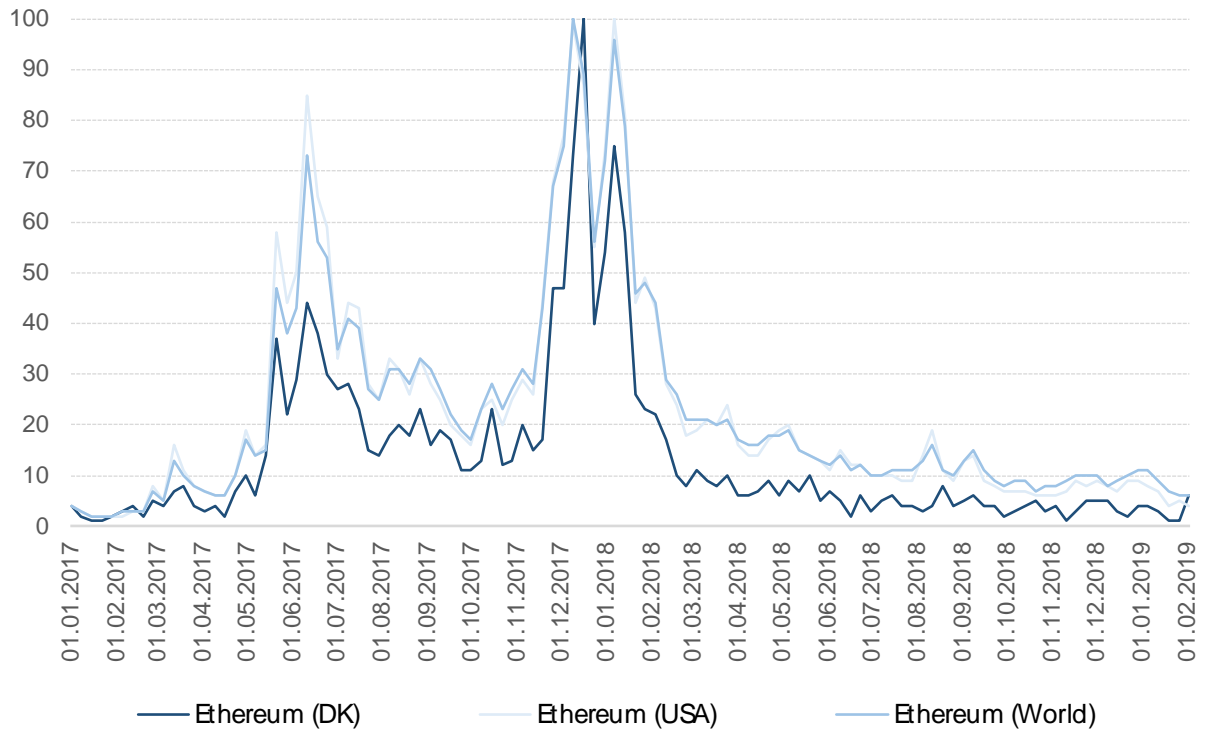


Figure 12: Google Trends data for Ethereum Denmark compared to USA and worldwide from 2017 to 2019

This descriptive analysis provides a high-level overview of the aggregate trends in the general public’s interest into the topic, as Google trends covers all searches at a given time and is therefore not focused on the tech or business sphere. Nevertheless, this social media analytics approach illustrates that there is significant interest in the cryptocurrency use case of blockchain technology. It clearly outweighs the interest in blockchain or DLT as such, as our search queries analysis indicates. This finding is in-line with a study conducted by Dansk Industri among its members in October 2018, which reported that only around 2 percent of the responding enterprises apply blockchain, while 3 percent are planning to use blockchain and 10 percent actively investigate the technology (Resultater fra DI’s Virksomhedspanel 4. kvartal 2018, Dansk Industri, Internal Analysis, Sept. 2018).

Blogs and Tech News Sites

Compared with the analysis of Google Trend search strings, discussions on different social media channels, forums, theme-specific websites can also be an indicator for the interest in blockchain in Denmark. While the blockchain community and interest is quite globalized, there are a few channels that are mainly aimed to serve the Danish blockchain community, and that is Bitcoin Talk Denmark, The Tokenizer and Copenhagen Ethereum Meetup.

Bitcoin Talk - Danmark (BTD) on Facebook Bitcoin Talk – Danmark is a Facebook group created for blockchain and crypto enthusiasts (Bitcoin Talk Danmark, 2019). In April 2019 it had 13,330 members and it was quite active with on average 9.5 new publications within 30 days. It is being administered by Danish blockchain startup ARYZE.

The Tokenizer (Website/Blog) The Tokenizer is a website covering blockchain topics, especially regarding tokenized assets, and was created only recently in February 2019 (The Tokenizer, 2019). It is not focusing particularly on Denmark but developed and managed by Norfico in Copenhagen (a Fintech consulting company).

Copenhagen Ethereum Meetup (<https://www.meetup.com/Copenhagen-Ethereum-Meetup/>) is an Ethereum developer forum with 1105 members regularly teaming up with the global Ethereum developer community. This is interesting due to the scarcity of precisely this resource.

Public and Private Sector Blockchain Initiatives

Regarding the public sector, the Danish government has showed their dedication of having a proactive strategy when it comes to advancing in digitalization and to facilitate growth for the development of technologies as highlighted in (Danish Ministry of Financy, Local Government Denmark, and Danish Regions, 2016). With that, there has been 38 specific initiatives that were a part of the November 2017 Agreement on Business and Entrepreneurial Initiatives that invested DKK 75 million in 2018, and DKK 125 million every year thereafter until 2025 that will go into strengthening the potential for companies to utilize new digital technologies and innovation (Danish Ministry of Industry, Business and Financial Affairs, 2018). Further, the Strategy for Denmark's Digital Growth report in 2018 stated that Denmark will be the first country in the world to use blockchain technology for registration of ships and certificates (Danish Ministry of Industry, Business and Financial Affairs, 2018). Another blockchain initiative that is supported by SKAT, the Danish Tax Administration is the registration as well as tracking and tracing of cars in Denmark by vehicle wallets. The wallets basically store the activities that a car has gone through during its lifetime (registration, technical inspections, changes in ownerships, maintenance, repair, etc.) (Berryhill, 2018).

Regarding the Public-Private Sector, Denmark has joined a handful of other countries on implementing a government-backed initiative called Sandboxes, which is an approach that supports startups and regulators to benefit from one another in a controlled space (International Finance Corporation, 2019).

Danish Blockchain Industry Cluster Analysis

Basically, it is important to understand that any cluster analysis only reveals the full economic importance for a country if all effects on the production and demand side are taken into consideration. Naturally, what is of importance are the jobs created in an emerging blockchain industry cluster, as well as the generated value related to the services required by specialized blockchain services providers (the production side). This is the core of the cluster.

On the other hand, the effects on the demand side for blockchain services (demand side) are equally of interest. In order to capture the direct and indirect contribution to the national gross domestic productivity, or value added, four different effects of investments into the blockchain industry cluster need to be taken into consideration, which are part of any macroeconomic multiplier analysis:

- **Direct effect:** comprises the value creation and employment of companies within the core blockchain services cluster. Those companies can be either provide primary blockchain-based services to third parties or companies that work on the development of blockchain technologies as such.
- **Indirect effect:** comprises the additional value creation and employment effect from wholesale demand of the blockchain cluster companies. The focus is therefore on companies that act as suppliers for the blockchain companies.
- **Induced effect:** comprises the additional value creation and employment effect that is created by the fact that the employees of the companies benefitting from direct and indirect effects spend their income again. This is a multiplier effect of the added value generated in direct and indirect effects.
- **Catalytic effect:** comprises the demand side benefit through the access to and availability of knowledge-intensive services thanks to the presence of a blockchain industry cluster. The catalytic effect is not easily quantifiable as it comprises spillover effects into other industries, which now can innovate and create new jobs and value in the presence of the blockchain industry cluster.

While this report focuses on the general economic effects of blockchain on Danish industry, it is worth mentioning that the emerging blockchain industry cluster is, also still very small, playing a crucial role for existing industries as a catalytic force to innovate.

Overview of the Danish Blockchain Cluster

In the following an overview will be provided of relevant blockchain actors in Denmark. While this research was done in a thorough way, many more start-ups and projects may have materialized in the meanwhile, so the list may require constant updating in a dynamic

area such as the emerging blockchain industry. For now, there are 16 organizations that have been identified as core blockchain cluster entities in Denmark.

The identified organizations are very heterogeneous, which is the reason why we grouped them into three innovation categories: start-ups, hubs or networks, and research. The entities identified are focus their services mainly in three sectors: FinTech (banking and insurance), maritime (trade) and general ICT services (information and communication, knowledge-based services). As seen in Figure 13, half of the identified blockchain organizations were active in the FinTech sector, closely followed by general services and ICT.

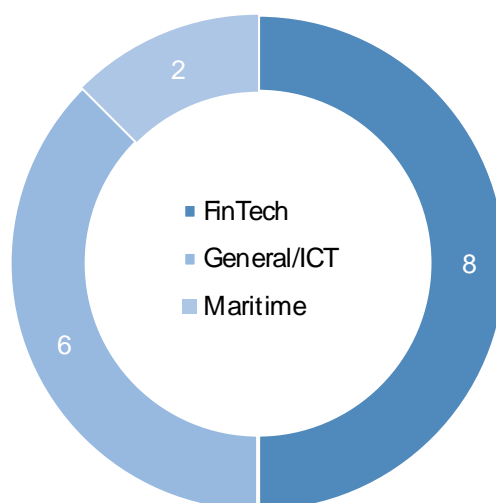


Figure 13: Identified blockchain-related entities by sector focus (Numbers given)

To elaborate in more detail on the blockchain organizations from the financial services industry, one of the largest was Coinify, which has over 50 partners and started its operations already back in 2014 (Coinify ApS, 2019). Coinify is a platform that offers currency trading and payment processing services. It is supported by organizations such as Nordic Eye Venture Capital, SEED Capital Denmark, SEB Venture Capital, and Accelerace. Another influencer in this sector is the Copenhagen FinTech and Copenhagen Fintech Lab, which describes itself as the Nordic FinTech hub. With that, their goal is to develop Copenhagen as one of the leading FinTech hubs in the Global Financial services industry by leading the way with technology driven corporate partners and start-ups. Further, they are supported by a handful of large partners, such as The Danish Industry Foundation, the city of Copenhagen, Finansforbundet (Financial Services Union Denmark), and Finance Denmark (association for banks, mortgage institutions, funds and others in Denmark).

The apparent lack of any larger blockchain initiatives among the Danish banking industry is a surprise, particularly as there are a lot of start-up initiatives not at least nurtured in the

mentioned Copenhagen Fintech Lab, with some of them internationally successful, such as Firmo, just to give an example. Firmo enables financial institutions such as cryptocurrency exchanges to securely offer decentralized derivatives to their customers and was recently bought by the trading platform EToro.

As for the Information and Communication sector, one example is the Openledger platform, which was also founded already in 2014 and currently lists seven projects and open position for 100 employees. They are a platform provider for various blockchain-related services, from being a trading platform to providing their own cryptocurrency. Openledger positions itself as a blockchain as a service provider. Another example in the Information and Communication sector would be Chainalysis, which is a company that has specialized on blockchain analytics and services that help to prevent or detect criminal activities such as money laundry, fraud, and other illegal activities. Currently, they have six investors and are also located in New York City and Washington D.C., in addition to Copenhagen.

Regarding the types of entities found in the Danish blockchain cluster, we clustered them into three categories, as seen in the Figure 8. Similar to the situation illustrated in Figure 14, start-ups are the largest group and represent three quarters (12 out of 15) of the entities. The remaining quarter is formed by three organizations that we grouped into the hubs/networks category, while there has been only one university research unit with the European Blockchain Center, that started doing blockchain research and education in 2016 (officially founded in the beginning of 2017).

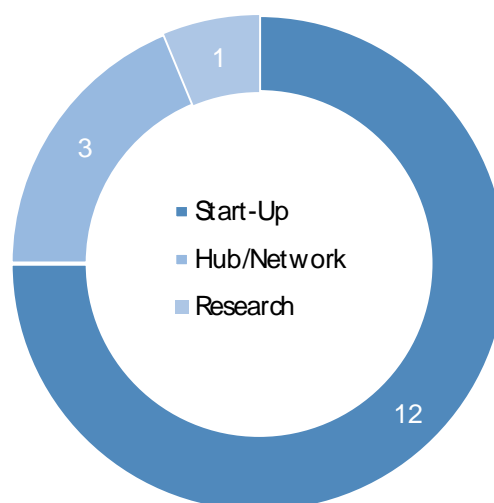


Figure 14: Identified blockchain-related org by type (Numbers given)

Following Figure 15 depicts an overview of blockchain-related organizations based in Denmark that our research was able to identify and that can be seen as the core of the emerging blockchain industry cluster.

Name	Contact	Type	Sector	Description	Estd.
ARYZE	aryze.io Købmagergade 22, 1150 København info@aryze.io	Start-Up	FinTech	Issues stable coins backed with traditional assets. Their wallet 'will let users send, receive and store currencies with no transaction fees'.	Q2 2017
BetterCoins	bettercoins.dk BetterCoins.dk ApS Kochsgade 31D, 2nd floor 5000 Odense C	Start-Up	FinTech	Bitcoin Exchange	?
Blockchain Labs for Open Collaboration	un-bloc.com Pier47 Langelinie Allé 47 2100 København Ø	Hub/ Network	Maritime	Hub for open collaboration. They created Maritime Blockchain Labs, a consortium for pilot projects	?
Blockshipping.io	blockshipping.io Blockshipping ApS Scion DTU, Agern Allé 24 2970, Hørsholm	Start-Up	Maritime	Blockchain freight container registry and platform to handle them	Q1 2018
BlockTech	blocktech.dk Applebys Plads 7 1411 København	Start-Up	General/ ICT	Small company (2 consultants and 2 developers) with a network of consultants that provide services related to blockchain	?
Chainalysis	chainalysis.com Strandgade 4 1401 København K	Start-Up	General/ ICT	Intelligence regarding transactions to prevent and detect money laundry, fraud and compliance violations. KYT Know your transactions suite (for AML)	?
Coinify	coinify.com Herlev Hovedgade 15B, 1. 2730 Herlev, København	Start-Up	FinTech	Platform offering currency trading and payment processing services. Backed by Nordic Eye Venture Capital, SEED Capital Denmark, SEB Venture Capital, and Accelerace	2014
Concordium	concordium.com	Start-Up	General/ ICT	Is developing an ID/KYC-focused blockchain,	?

	Aabogade 15 8200 Aarhus N			strong support of prominent advisors, originating from Aarhus University, Concordium Foundation located in Switzerland	
Copenhagen FinTech and Copenhagen Fintech Lab	copenhagenfintech.dk Applebys Plads 7 1411 København K	Hub/ Network	FinTech	Vision: Develop Copenhagen as one of the leading FinTech Hubs in the global financial services industry by supporting and catalyzing the next era of technology-led corporate and startup innovators.	2009
EKOFOLIO	ekofolio.com Kalvebod Brygge 39-41 1560 København V København	Start-Up	FinTech	Marketplace for forestry. Plan is to back investment (tokens) with tangible assets (forests)	Q1 2017
e-Money	e-money.com Aarhusgade 88, 3 DK-2100 - København Ø	Start-Up	FinTech	Global transactions of digital money	2016
European Blockchain Center - EBC	ebccenter.eu IT University of Copenhagen	Research	General/ ICT	Mission: Being the globally leading institution that understands, creates, and realizes blockchain-based solutions in a cross-industry and cross-disciplinary private public partnership to generate value for society. Organized Blockchain Summer School (Copenhagen Business School, Copenhagen University and IT university)	Q1 2017
Firmo	Copenhagen Fintech Lab Applebys Plads 7 1411 København K	Start-Up	FinTech	Financial derivatives in the blockchain space	2017
Nordic Blockchain Association	Univate - Njalsgade 76, 2300 København	Hub/ Network	General/ ICT	NBA helps to "build impactful organizations, solutions and networks, that utilize blockchain and DLT" within the Nordic area.	?

OpenLedger	OpenLedger ApS, Copenhagen Fintech Lab Applebys Plads 7 1411 København	Start-Up	General/ ICT	Blockchain related products (trading platform, own cryptocurrency), blockchain as a service. Services: consulting, advisory, marketing, ICOs, crowdfunding, etc.)	2014
Puut	puutwallet.com Copenhagen Fintech Lab Applebys Plads 7 1411 København K	Start-Up	FinTech	Producing claims to be world's most ambitious Global Wallet	2014

Figure 15: Overview of blockchain-related entities based in Denmark (Est. = Established)

Danish Supply Chain Industry Blockchain Actors

The overall findings of this report suggest that blockchain can be regarded as a technology that greatly will improve especially supply chain management and vehicle connectivity. However, a critical view on the technology also reveals its current shortcomings and potential pitfalls.

The two Danish blockchain initiatives in the supply chain industry cover classic supply chain areas such as Tradelens with the bill of lading on blockchain, or in a more untraditional way to address long-existing business challenges as Blockshipping is doing by improving the turnaround and management of containers to reduce costs. As the maritime industry is strong and has a long history in Denmark, it is fair to assume that there will be significantly more blockchain initiatives in this industry in the near future.

In order to have a comprehensive view, we have also covered related blockchain supply chain initiatives outside Denmark, however the focus is on the Danish cluster. The following is a list of typical blockchain use cases in the industry of supply chain management. The SCOR¹ model activities they impact are mentioned.

¹ The SCOR - Supply Chain Operations Reference is a model that describes the six primary management processes in a supply chain related with customer's demands satisfaction: plan, source, make, deliver, return and enable (APCIS, 2018).

#	Typical use case	Description	Blockchain-based system's properties ²	Related SCOR activities
1	Asset registry	Ships are registered in a blockchain allowing open, secure and efficient ship registration. The records can be access by authorities, owners and other interested parties. This complements other digitalization efforts for improving supply chains.	Immutability of records Time stamping Cryptographically secure	Enable
2	Tracking of goods	Goods like food, medicines, electronics, and luxury commodities can be tracked during their journey through the supply chain. IoT enabled packages allow to record variables like temperature, pressure and location and then this information is stored in a shared ledger that can be accessed by all participants in the chain. This is especially useful when the conditions of the transport of goods are important like vaccines, medicines, flowers and food where temperature must be controlled.	Decentralization ³ Time stamping	Deliver Return Source Enable
3	Provenance	Goods are tracked from end to end in the supply chain; information like their origin, location, transport conditions, producer and batch is stored in a blockchain. This allows the customer to know exactly where the goods they buy come from, thus bringing transparency, trust and allowing a better-informed purchase decision and detecting fraud. In cases of food tracking it also enables authorities to rapidly identify the origin of contaminated food and allows a rapid action against foodborne diseases.	Immutability of records Decentralization Time stamping Cryptography	Source
4	Tracking of containers	IoT enabled containers are tracked providing end-to-end supply chain visibility that enables all actors involved in a global shipping transaction to exchange shipment events in real time. The information can also be analyzed and used to improve efficiency and reduce costs. Transports and logistic companies can share (e.g. rent) containers and optimize usage.	Immutability Time stamping	Deliver Return

² It is good to clarify that these are not always blockchain technology properties but rather the properties of a blockchain-based system. See (Buterin, 2017).

³ There are different axes of decentralization (Buterin, 2017). Depending on how a use case is developed, the property of decentralization may or may not be met. It may possible for example that a use case is implemented with a "blockchain" which records are stored in a distributed manner over several nodes and yet be under the control of a single company. In this case the system is architecturally but not politically decentralized thus not being a blockchain by definition.

5	Operations transactions	Using the smart contract feature, national and international operational transactions are digitalized and automated. Every participant in the supply chain including transporters, authorities, customs, and insurers can submit, stamp and approve or reject digital documents. This reduces the transaction times, costs, allows port to port collaborations, better informed risk assessments, improve assets (containers, ships, trucks) planning.	Automation ⁴	Deliver Enable
6	Insurance shared ledger	Marine insurance risk information including ships, containers, routes (outside and inside war zones) is stored in a blockchain and shared among all parties involved thus serving a source of truth for all. The benefits include significant time reduction of premiums settlement and claims payments as well as real time risk visibility of assets. Smart contracts allow to automate agreed rates to change according to risk and settle claim payments.	Decentralization Immutability of records Time stamping Automation	Enable

Figure 16: Typical blockchain use cases in the supply chain management (systemized by SCOR)

Projects and Proofs of Concept

Asset Registry

Danish Maritime Authority

In line with the digitalization efforts of the maritime industry, the DMA created a project in 2017 that uses blockchain to register ships by the owners. Actually, owners must fill and handle all related forms manually. The intention is to build a proof of concepts that helps to “clarify whether blockchain technology could support the Danish Maritime Authority's digitalization efforts positively and help bring about an open, secure and more efficient approach to the date recorded in the registers of shipping” (Danish Maritime Authority, 2017).

⁴ Understanding automation more like a feature than a property, present in some blockchain platforms like Ethereum and Corda.

Tracking of Goods

Blockverify.io

It is a blockchain solution that tracks goods over a supply chain and store its information on a ledger. In its official webpage they list 4 use cases in pharmaceuticals, luxury items, electronics and diamonds.

The concept is to tag every article with a unique id and verified along the supply chain. The final user can verify with a smartphone that the product is genuine and activate it at the moment of purchase.

IBM-SAP pharma use case demo

IBM partnered with SAP to develop a demo in which IBM blockchain technology integrates with an already existing and running SAP system in order to create a tracking system for pharmaceutical products.

The demo: An IoT enabled package containing a pharmaceutical product that has to be transported keeping a cold chain. The package transmits its status as it goes through the supply chain passing through multiple carriers. This information is stored in a blockchain and every time the cold chain is broken it send immediate notification allowing to take correct action and enforcing compliance.

Mediledger

It is a group of work integrated by big pharma and some tech companies including Pfizer, Roche Group, AmerisourBergen, and Chronicled (the developer) created in 2017 to gather leaders of the pharmaceutical industry, manufacturers, distributors, SCM experts and other with the aim to analyze the impact of blockchain technology for the industry.

The project created an Ethereum-based platform prototype to demonstrate how blockchain could help the industry participants to comply with the DSCSA requirements and its own operational expectations. After implementation and testing the prototype fulfilled all the requirements and expectations (MediLedger, 2018).

Bloc Gemini

Blockchain-based company. It has developed a “Global Trade & Finance Management Platform”. It was first developed as a Supply chain solution for Tristar Transport group in UAE, is currently operational since 2017 and is now offered openly to other companies.

There are not many details about the scope of the platform rather than allowing interested parties in a supply chain to have relevant information available. According to the official webpage the platform is smart contract enabled and includes the possibility to realize digital payments. They offer services that include custom BC solutions, consulting, IoT, IIoT,

AI, ML integration, Dapps and smart contract developments (Block Gemini Technologies, 2018).

Provenance

Provenance.org

It is a blockchain platform that intends to give final customer information about “how and where the products are made” (Baker, 2015). The platform stores in a blockchain the information related to the origins of products including where they were produced, who produced them, whether the producers meet certain working standards, among other metrics that can make allow customers to make a more and well-informed purchase decision. For that the information in the blockchain is made completely public (Provenance, 2015).

Everledger

Everledger is a global startup that uses the best of emerging technology including blockchain, smart contracts and machine vision to assist in the reduction of risk and fraud for banks, insurances, and open marketplaces (Everledger, 2018). The company developed a global digital ledger that records information about the lifecycle of valuable assets. A product is identified by a unique tag created on basis of its physical characteristics, with this tag different stakeholders can verify authenticity and provenance.

IBM-Walmart blockchain for food safety

IBM and Walmart partnered to develop a blockchain that allows Walmart’s customers to check where the food they are buying was produced and under what conditions. They use IoT technology and traceability techniques to store in a digital ledger the provenance information of the products they sale. Walmart’s final goal is to provide transparency and trust to their customers by letting them know not only the provenance of their products but also ensuring that the right products are removed when there is a food event or food scare (IBM, 2017).

Tracking of Containers

SmartLog Project

SmartLog aims to create a blockchain-based log of all the information related to the movement of intermodal containers throughout the European Union transport corridors. It uses hardware technology to track containers and make this information available to interested parties in the supply chain. The data generated is more intended to be used

machine-to-machine, although tools will be integrated to allow human interaction and visualization (Smart Log Blockchain Logistics, n.d.).

Its market focus is not necessarily commercial, but rather to be an industry level platform from which all interested companies can get information from. It is based on the IBM's Hyperledger fabric. The project is led by Kouvola Innovation Oy but includes public and private institutions from Sweden, Latvia and Estonia. It uses funds from the EU's Interreg Central Baltic program. A demonstration was conducted in June 2017 in Estonia's largest cargo port. Ten sea containers were tracked, and the information was fed into the blockchain by ten different companies.

Blockshipping.io

Danish company. The project is currently under design and prototyping of a blockchain platform called the Global Shared Container Platform (GSCP). The platform aims to provide a global container asset registry that includes the more than 27 million containers in the world. Their goal is to reach 60 percent of these in 3 years. It aims to provide not only registration information about the container but also real time location and status through IoT technology.

According to its whitepaper, the blockchain-based GSCP allows (Blockshipping, 2018) for asset registration information, container location thus facilitating the grey box concept to be implemented (shared pool of containers to match demand of carriers in specific locations allowing significant cost reduction), and container asset related transactions like payments and other processes.

Operations and Transactions

IBM-Maersk Joint venture Tradelens

Joint venture between IBM and Maersk announced on January 2018. The new company developed an open global trade platform based on blockchain IBM's Hyperledger project. It was not specifically designed for the shipping industry but rather for global trading processes in general. Nevertheless, 80 percent of daily consumed goods are transported by the shipping industry and for this it was used for proof of concept and first applications.

The company is developing the platform on an "open technology stack" but plans to commercialize it (not specific date yet). The first commercial plan includes two functionalities related to the digitalization of global supply chains from end-to-end that aim to solve visibility and documentations challenges.

According to IBM's blog page (White, 2018) it includes shipping information made visible in real time to all actors involved in the supply chain, as well as paperless trade that aims to automate paper-based transactions allowing end-users to "securely submit, validate and approve documents across organizational boundaries" reducing cost and time of ship clearance.

This ambitious project is designed to involve all the actor in the supply chain from end to end thus including and claiming to provide benefits for ports and terminals, ocean carriers, customs authorities, freight forwarders, intermodal transporters and shippers.

The first independent port in US to pilot this solution is Holt Logistics Corp. located in the northeastern United States. The announcement was made by the end of April 2018 (Holt Logistics Corp. , 2017).

Insurance of Assets

EY - Maersk blockchain platform for shipment insurance

This is a collaboration project in which EY, Guardtime, Maersk, Accord, Microsoft and other companies participate. It is led by the first two. This blockchain enterprise-scale platform is intended to provide value to the insurance industry in general, nevertheless at the beginning the focus is only on the marine industry. This decision was motivated by the current characteristics of the marine business industry: complexity, cross borders, number of parties involved, digitalization opportunities.

The platform is designed to record data about identities, risks and exposure and link it through smart contracts to automate transactions related with the insurance of shipping industry. This allows insurers to deliver insurances in a more efficient way and other supply chain actors to resolve claims faster and automate payments through smart contracts.

The platform allows to create and maintain asset data from multiple parties, link data to policy contracts, receive and act upon information that results in a pricing or a business process change, connect client assets, transactions and payments, and capture and validate up-to-date first notification or loss data.

The major positive impacts are gathered in four areas:

- Policies: It simplifies data collection for the policies issuance (nowadays it may take months). It helps making policies suit better the client's needs, it facilitates reconciliation of premiums and payments.
- Declarations: Real time-shared information among parties. Real time notification of contract changes (name of the ship, crew, flag, etc.) to brokers, authorities, owners, insurers.
- War zone shipping: It reduces the complexity, time and costs automating calculation of prearranged rates and risks when a ship goes through war zones.
- Claims: all parties involved work on the claim based in the exact same information (allows some forensics). Payment times are significantly reduced.

Current state: In September 2017 it was informed that the platform was "launched" after a 20-week proof of concept. There are no more details (EY, 2017).

C EMPIRICAL SURVEY-BASED ANALYSIS

This chapter presents the results of an empirical analysis based on a comprehensive survey of Danish companies performed in January and February 2019. Goal of the empirical analysis is to get an insight into the current state of the art of blockchain technology as well as of its drivers and hurdles and future developments in the Danish economy.

We first describe the methodological background and basic parameters of the survey. Then we present the descriptive results of the empirical analysis before we dive deeper into the data to investigate causal relationships through a Structured Equation Model.

Empirical Approach and Basic Parameters of the Study

A quantitative research methodology was chosen in order to be able to capture current interrelationships and numerical characteristics in the larger scope of the Danish economy. Using a fully standardized questionnaire, central company data as well as data on the current and planned use of the blockchain were queried. The target group were companies based in Denmark. The selection of the specific sample and the implementation of the survey was carried out by *Danmarks Statistik*. Danmarks Statistik also provided the competence in crafting and rolling out the questionnaires.

The survey was rolled out and conducted between January and February 2019 and pre-tested using a smaller sample in December 2018. The pre-test results helped us to refine the final set of questions. The data was collected through telephone interviews as well as by using an online poll tool. Figure 17 provides a brief general descriptive of the study.

Sector Focus	From Danish industry, 28 sectors were selected using the Danish Sector code DB07. Then, the 28 were clustered into 6 sector-groups which we use in this analysis, as well as in 4 size groups, starting with companies employing more than 10 employees.	
Key Informants	CEOs or executive level employees with insight into corporations the company's IT-strategy and organization	
Survey Period	January/February 2019	
Method	Fully standardized questionnaire; online, telephone	
Response Rate	Sample size	3,013
	Responses	1,329
	Response rate	44.1 %

Aspects Covered	
	1. Organization and Strategy of the Company
	2. Innovation Environment
	3. Digital Position
	4. Performance Parameters
	5. Specific Performance
	6. Environment of the Company
	7. Blockchain Engagement
	8. Potential Use and Specific Application of Blockchain
	9. Blockchain Challenges
	10. Future Effects of Blockchain
	11. Management's Insight into Blockchain

Figure 17: Method and structure of the survey

Composition of the Sample

The data sample with a response rate of over 44 percent of the approximately 3,000 companies surveyed allows for a very robust empirical analysis of the digital innovation dynamics when it comes to blockchain in Danish industry. In the following, we will illustrate the structure and demographics of the data sample. A large variety of different kinds and sizes of companies is essential as a sufficient variance in the data is necessary in order to draw conclusions regarding the industry sectors under consideration, as well as the IT innovation patterns and blockchain projects and plans.

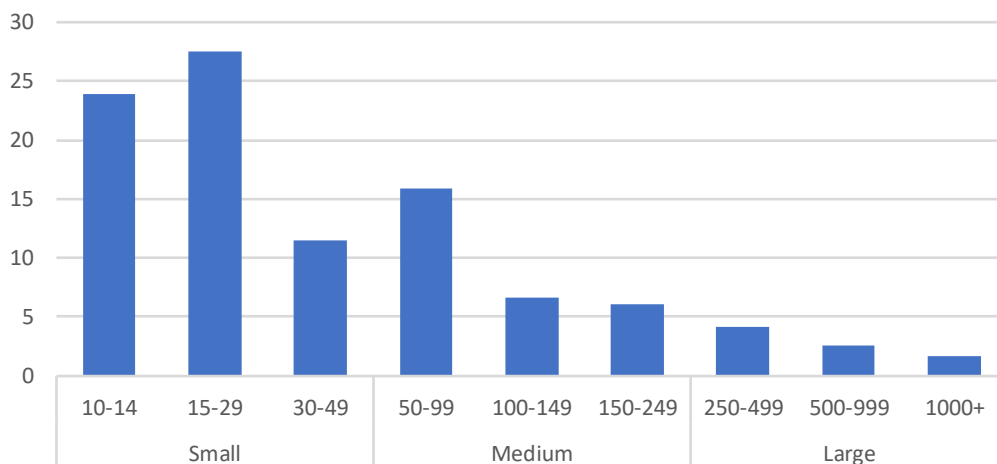


Figure 18: Composition of the sample by company size: according to the number of full time employees (FTE) (n=1329)

An analysis of the company size on the basis of the number of employees and the revenue in 1,000.- DKK in the last four quarters shows that a large number of company size segments are represented in the sample (Figure 18 and Figure 19). Micro, as well as Small

and Medium-sized enterprises (SMEs) are equally represented in the sample, as well as large enterprises. We classify the companies into the size categories according to Eurostat⁵.

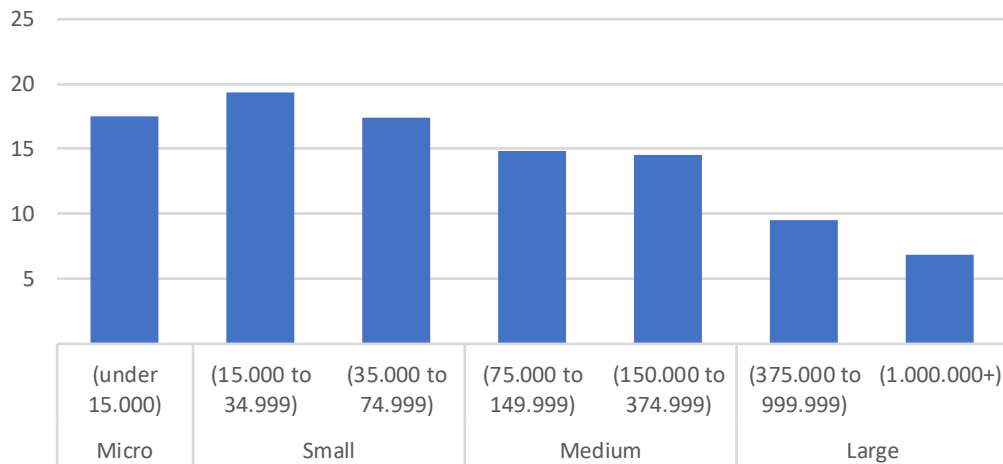


Figure 19: Composition of the sample by company size: according to the revenue in the past four quarters (in 1,000. – DKK revenue) (n=1329)

The next Figure shows the composition of the sample according to industry sectors (Figure 20).

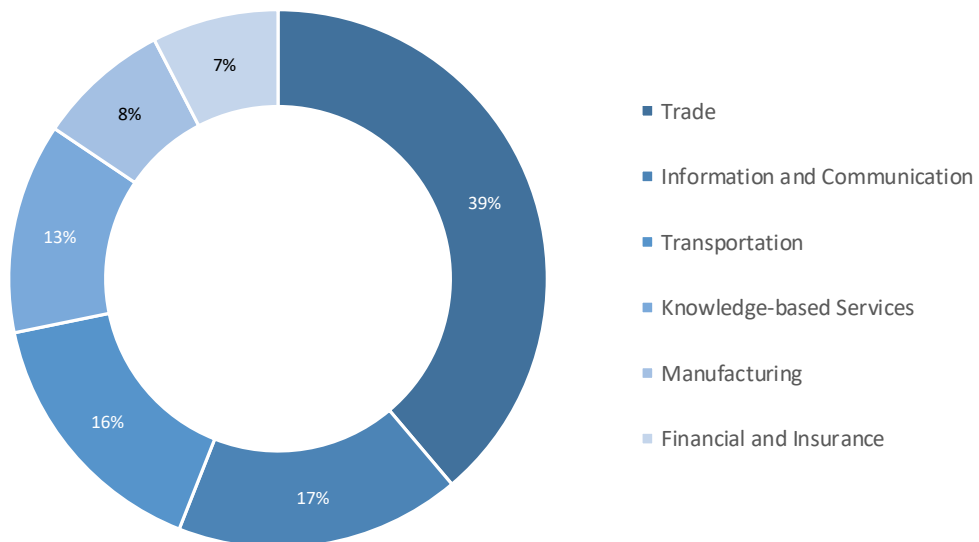


Figure 20: Composition of the sample according to industry sectors (n=1329)

The sample's basic data shows that a balanced sample can be generated that offers enough variance. We therefore expect that the study can provide valuable insights into business practices regarding blockchain in the analyzed Danish industries.

⁵ See <https://ec.europa.eu/eurostat/web/structural-business-statistics/structural-business-statistics/sme>

Descriptive Results on Blockchain in the Danish Economy

Next, we will descriptively present the state of the art of blockchain in the Danish economy.

Current Knowledge and Application of Blockchain Technology

This section observes the empirical results that give an impression on the current knowledge and application of blockchain technology in Denmark. It considers the differences between so-called “top performers” vs. “followers”, “digital leaders” vs. “digital followers”, as well as “strong innovators” vs. “followers”.

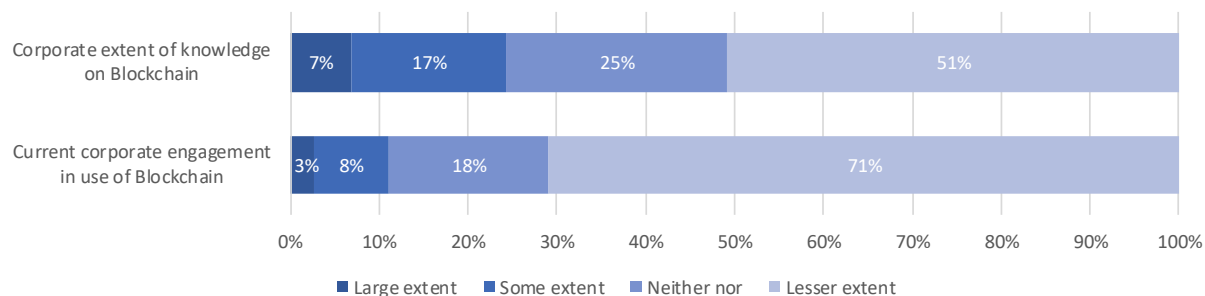


Figure 21: Extent of current knowledge and engagement in use of blockchain by companies in the sample (n=1114, n=532)

Overall, Figure 21 gives insight to the current knowledge level of blockchain at a corporation level. Around 75 percent of corporations answered with having only some extent of knowledge about blockchain. Only eleven percent of the companies in the sample are at least to some extent engaged in blockchain.

Only 7 companies in the sample have already abandoned or discontinued activities connected to blockchain.

Figure 22 highlights to which extent the corporations are knowledgeable about blockchain. The company sizes are categorized into multiples of 1,000.- DKK revenue. One can observe that both large and micro sized companies are sharing similarities in percentages of knowledge, with comparable knowledge on blockchain. Large companies could have the resources to invest in new research and innovations such as blockchain technologies, while micro companies would include start-up companies that are inspired by blockchain.

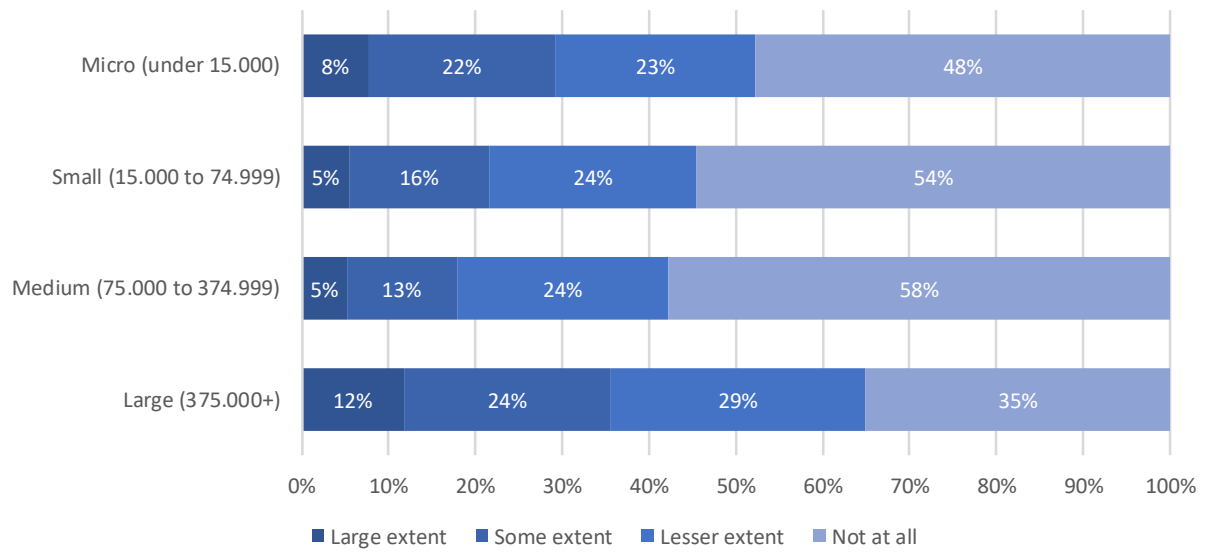


Figure 22: Extent of current knowledge on blockchain (by company size in 1,000. - DKK revenue) (n=1103)

Another insight that is intriguing is to review the industries that have taken an interest to become more knowledgeable in blockchain technology. For instance, it is no surprise that the financial and insurance industry possesses a larger extent of knowledge on the technology, given the interest of Bitcoin in the last years and the question of the impact of cryptocurrency on the financial services industry or the importance of Fintech.

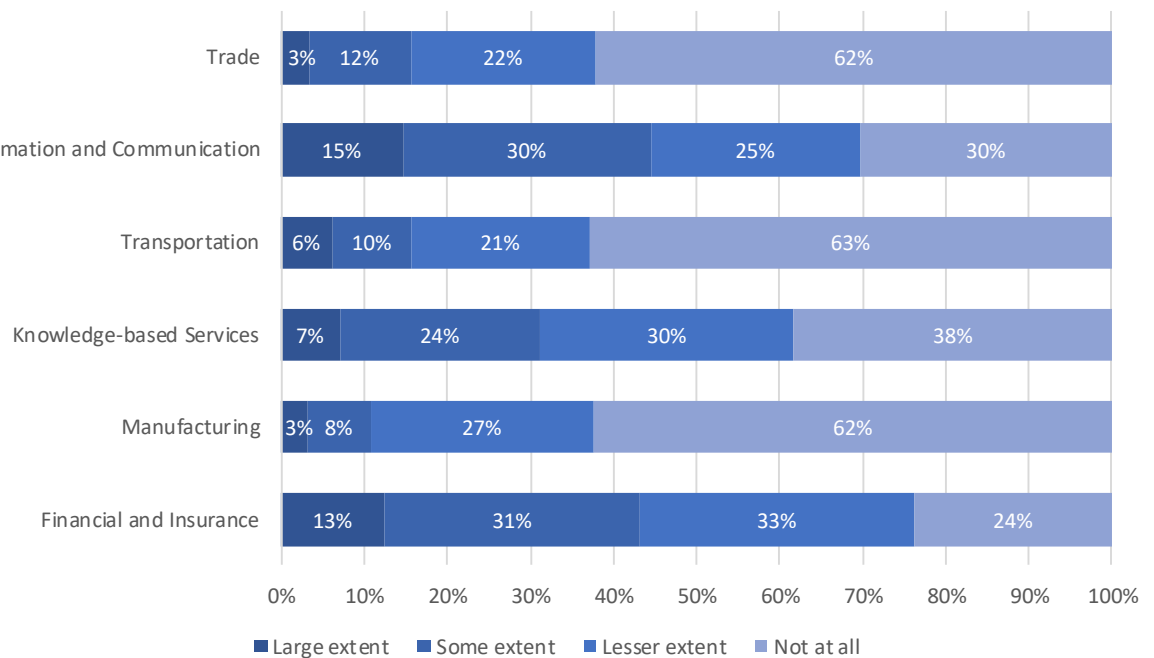


Figure 23: Extent of current knowledge on blockchain (by industry sector) (n=1114)

Another industry with a similar extent of knowledge on blockchain from corporations is the information and communication technology sector, given that this sector is heavily driven by technologies such as blockchain. Other Industries report around 30-40 percent of at least some extent of knowledge about blockchain technology, such as the transportation and manufacturing industry. Logistics and shipping in particular have taken a great interest on implementing use cases of showcasing how the shipping industry could benefit from blockchain in regard to registration and certificates on the blockchain (Dobrovnik, et al., 2018).

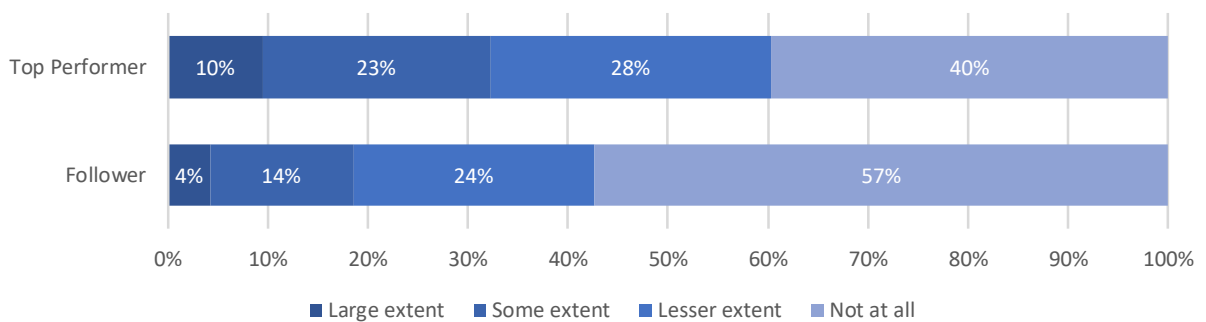


Figure 24: Extent of current knowledge on blockchain (by company performance) (n=528)

If we look into the area of reported company performance⁶, one can see that top performers are ahead of competition in terms of being able to inform themselves and becoming more knowledgeable about blockchain technology. In addition, at least 33 percent of top performers have large or at least some knowledge about blockchain, while this is only the case for 18 percent in the follower group.

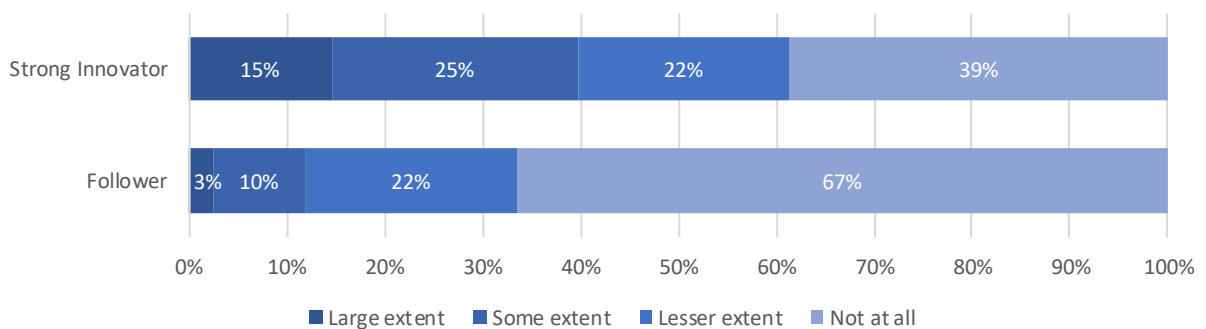


Figure 25: Extent of current knowledge on blockchain (strong innovators vs. followers) (n=472)

⁶ We formed two groups of companies in our sample to perform comparisons according to economic performance: Top Performers and Followers. Companies in these two groups differ in their self-assessment of current economic performance over several indicators (whether: the company is progressing these years, 2019 will be a better year than 2018 measured on the annual result, in 2019 it will increase number of employees compared to 2018, in 2019 it will invest more than in 2018).

Meanwhile, strong innovators in comparison to followers⁷ have a large majority of 40 percent illustrating at least some extent of knowledge on blockchain alone. Followers are far behind, where only 13 percent exhibit some extent of knowledge on the technology as well. With that, followers lead a majority of having 67 percent that have no current knowledge of blockchain, while strong innovators sit at 39 percent.

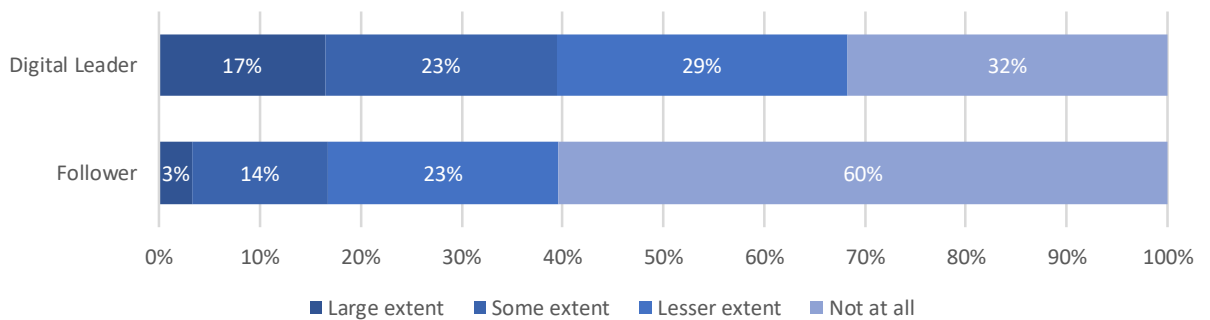


Figure 26: Extent of current knowledge on blockchain (digital leaders vs. followers) (n=784)

As for the differences between digital leaders and followers⁸ (Figure 26), the followers report to have a majority of no knowledge at all on blockchain at 60 percent. While digital leaders show to have 40 percent of having at least some extent of knowledge on blockchain and 17 percent of that knowledge is at a large extent.

Even though there is a large majority between 65 to 80 percent of the firms of all sizes that have no current engagement related to the use of blockchain technologies (Figure 27) it is impressive that 15 percent of large companies and 12 percent of medium sized use at least some extent of blockchain technologies, given that it is such a young technology.

⁷ We formed another two groups of companies in our sample to perform comparisons according to how innovative a company is: Strong Innovators and Followers. Companies in these two groups differ in their self-assessment of openness to and accepting innovation over several indicators (whether or to which extent the company is willing to accept innovation based on research, management actively encourages innovative ideas, innovation is immediately accepted in the corporation, employees are blamed or punished for implementing innovations or innovative solutions that do not work, innovation is regarded as an opportunity rather than a challenge or risk).

⁸ Another two groups of companies in our sample are formed to enable comparisons according to how digitalized a company is: Digital Leaders and Followers. Companies in these two groups differ in their self-assessment of the level of digitalization in their company (is the company a leader use of IT or a digital late-comer).

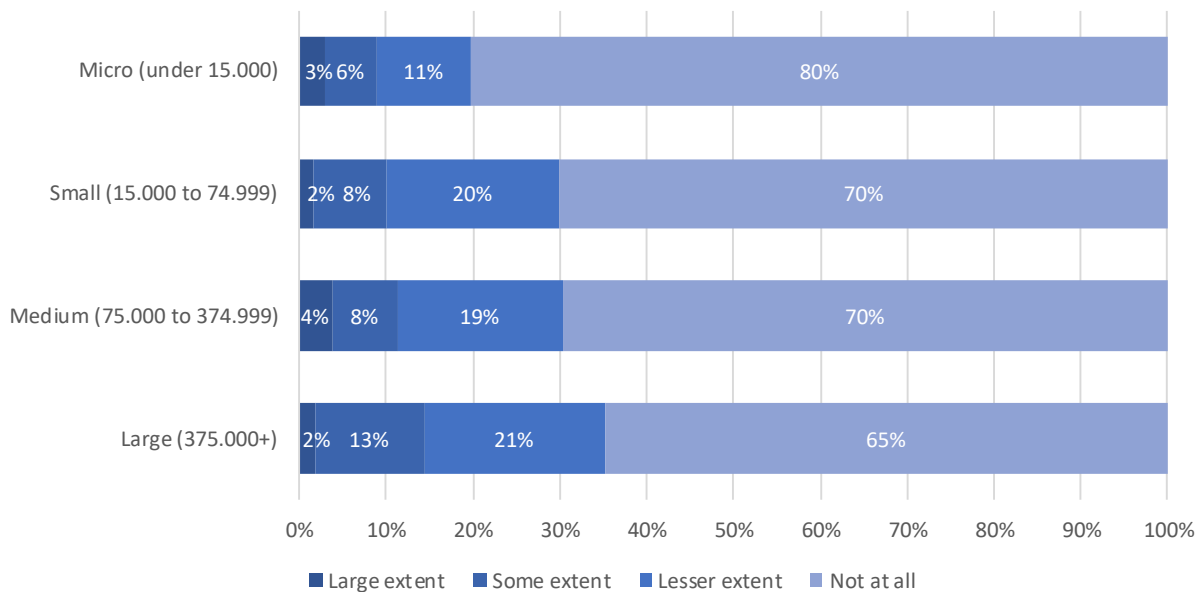


Figure 27: extent of current engagement in the use of blockchain (by company size in 1,000.- DKK revenue) (n=524)

Figure 28 shows which industries are currently working with blockchain. Overall, around 70-80 percent of corporations in the related industries are not working with blockchain. Of the industries that are, the leading three industries are knowledge-based services, information and communication technology, and trade.

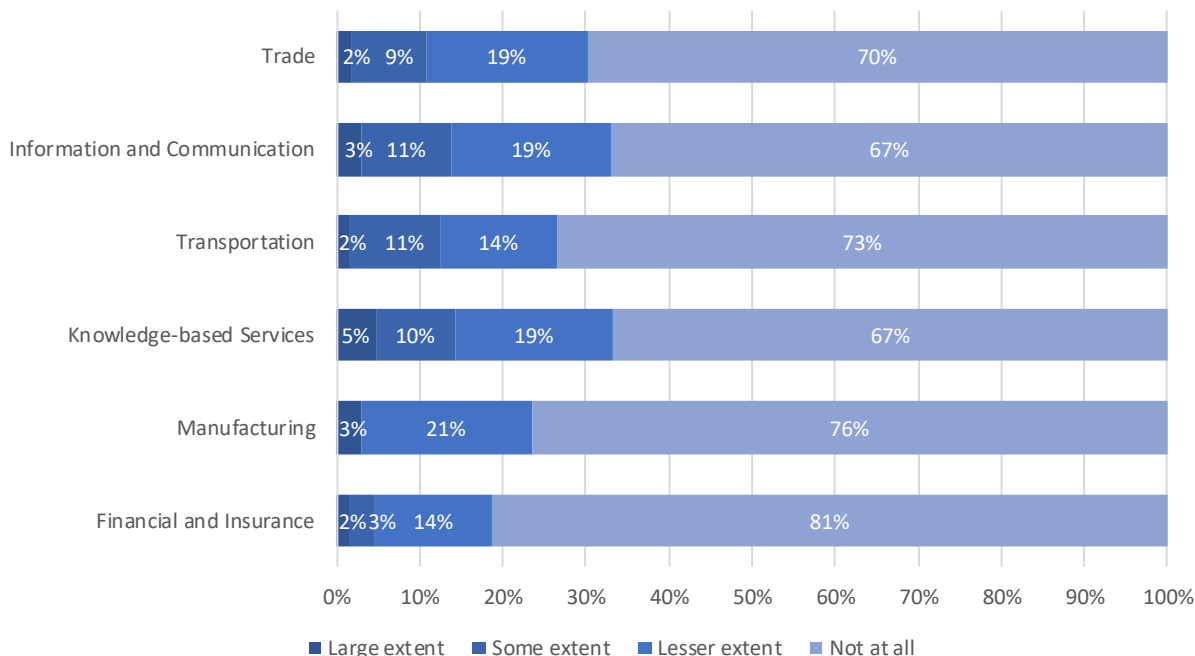


Figure 28: Extent of current engagement in the use of blockchain (by industry sector) (n=532)

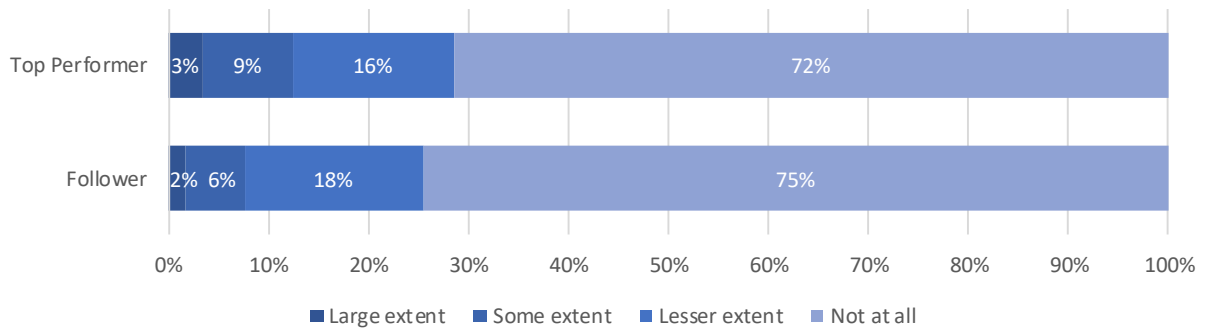


Figure 29: Extent of current engagement in the use of blockchain (by company performance) (n=262)

Of the group of top performers and followers that answered (Figure 29), it can be observed that the top performers had roughly similar amounts of engagement, where the differences in percent varied less than 10 percent of one another.

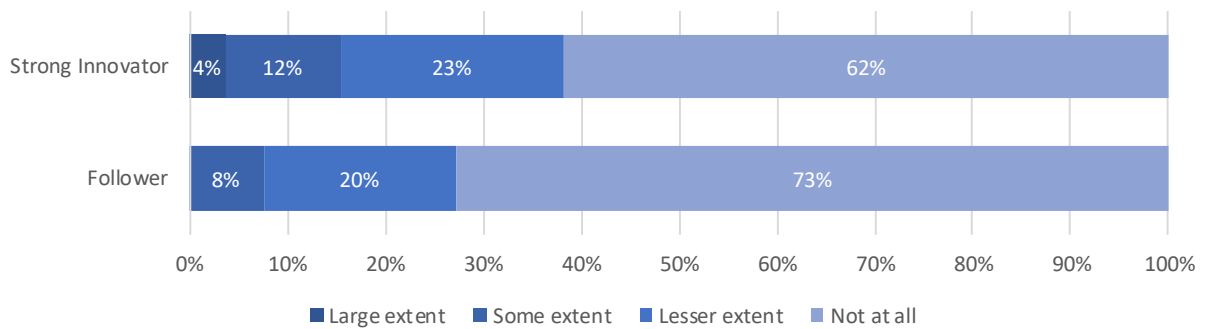


Figure 30: Extent of current engagement in the use of blockchain (strong innovators vs. followers) (n=228)

Regarding the group of strong innovators and the followers' engagement in the use of blockchain activities, the strong innovators reported a slightly higher level of engagement, but overall it was roughly the same result for both types of companies. They showed similar trends of having a strong majority of not having any involvement in blockchain activities (62 percent strong innovators, 73 percent followers).

In Figure 31: Extent of current engagement in the use of blockchain (digital leaders vs. followers)) can be seen, and one can observe to which extent corporations, who fall into either the category of digital leader or follower, are in their current engagement with using blockchain. The digital leaders are more engaged than the followers, which is to be expected, however the distribution of engagement is similar.

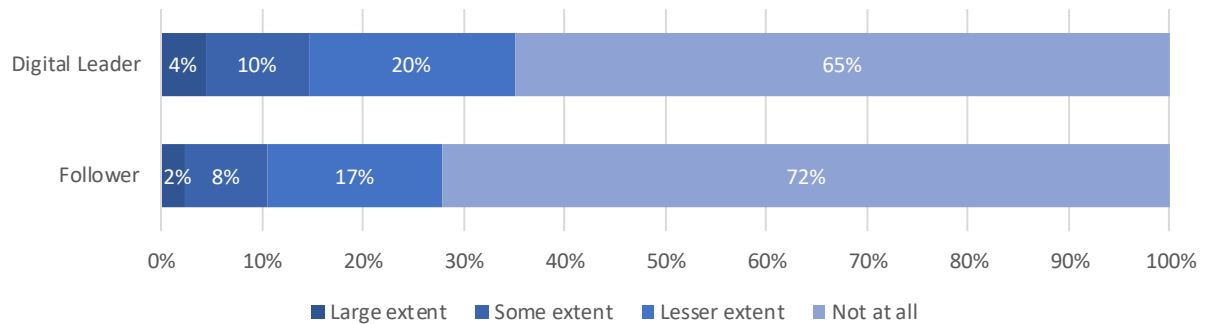


Figure 31: Extent of current engagement in the use of blockchain (digital leaders vs. followers) (n=365)

As for participation in various blockchain-related activities, which considers if the company has started to exploit blockchain-related activities, started working on various projects that support blockchain, tested a proof-of-concept, or have had several implementations of blockchain in business processes. This graph gives an interesting representation of which phase companies are at in implementation of blockchain-related activities.

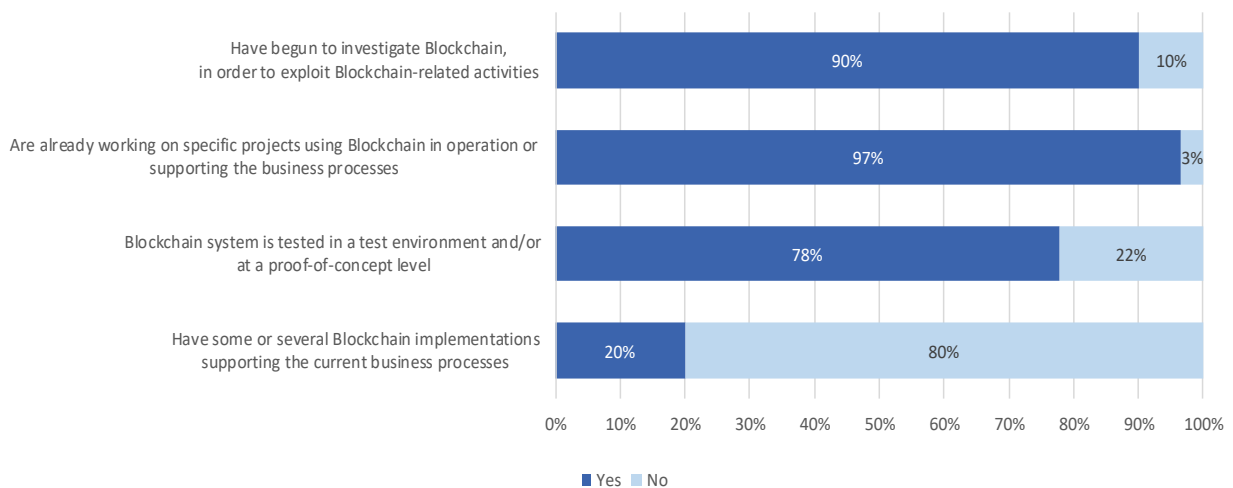


Figure 32: Type of blockchain-related activities (n=127, n=125, n=27, n=125)

A great majority (90 and 97 percent) of companies have investigated and started working on specific blockchain related projects. With still a great majority of the corporations (78 percent) have used stated to have tested blockchain proof of concepts. However, the actual implementation of blockchain is a phase that is yet to have been reached for many companies (80 percent have not implemented blockchain).

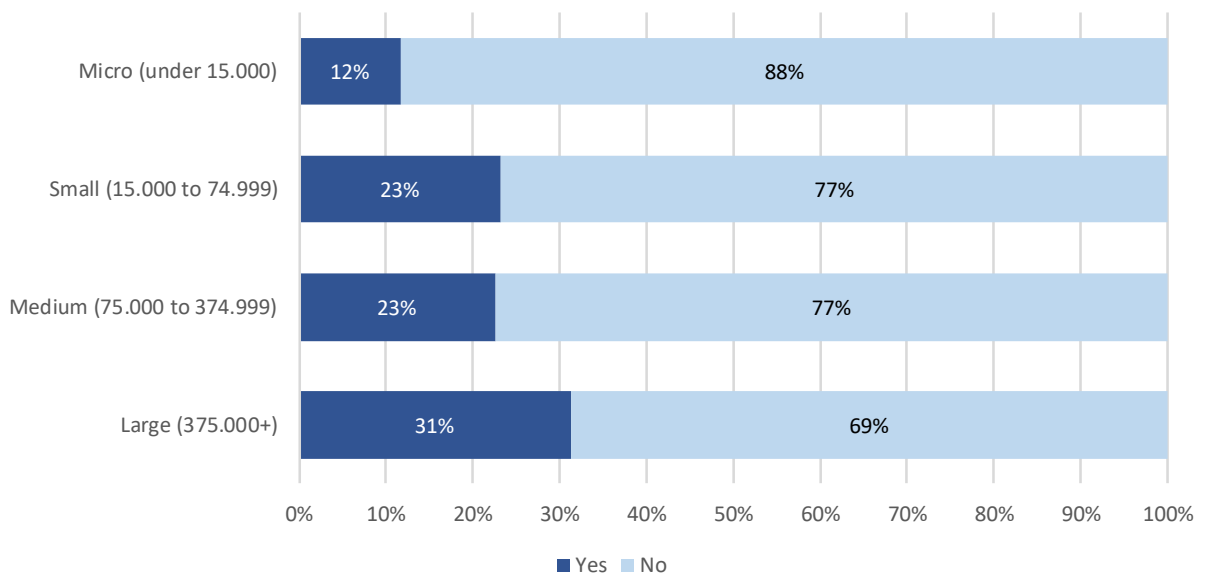


Figure 33: Is the corporation already working on specific projects using blockchain in operation or supporting the business processes? (by company size in 1,000.- DKK revenue) (n=123)

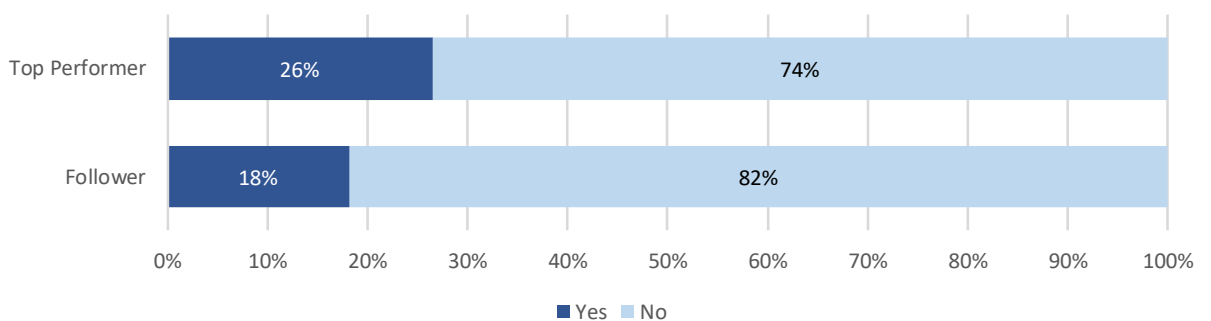


Figure 34: Is the corporation already working on specific projects using blockchain in operation or supporting the business processes? (by company performance) (n=56)

In Figure 33, it can be observed that despite the size of the company (in revenue) that most are currently not working on specific projects using blockchain in operation or supporting business processes (69 - 88 percent). Furthermore, Figure 34, Figure 35, and Figure 36 look at various types of corporations that are working on specific projects using blockchain, such as those who are categorized as top performers vs. followers, strong innovators vs. followers, and digital leaders vs. followers. Overall, we see that corporations are largely not working yet on specific projects using blockchain as a means to support their business processes. There appears to not have any major differences between these characteristics, aside that the more ambitious appear (top performers, strong innovators, and digital leaders) to have more blockchain-related projects than followers. Strong innovators have more than double blockchain-related projects than the followers.

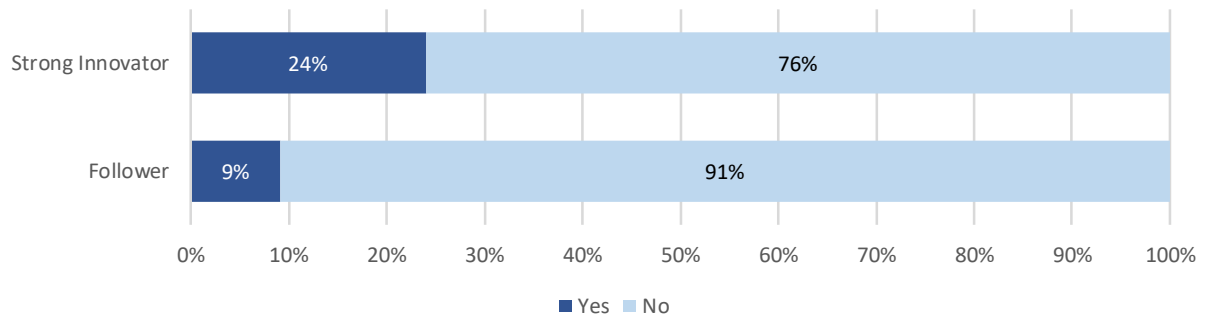


Figure 35: Is the corporation already working on specific projects using blockchain in operation or supporting the business processes? (strong innovators vs. followers) (n=61)

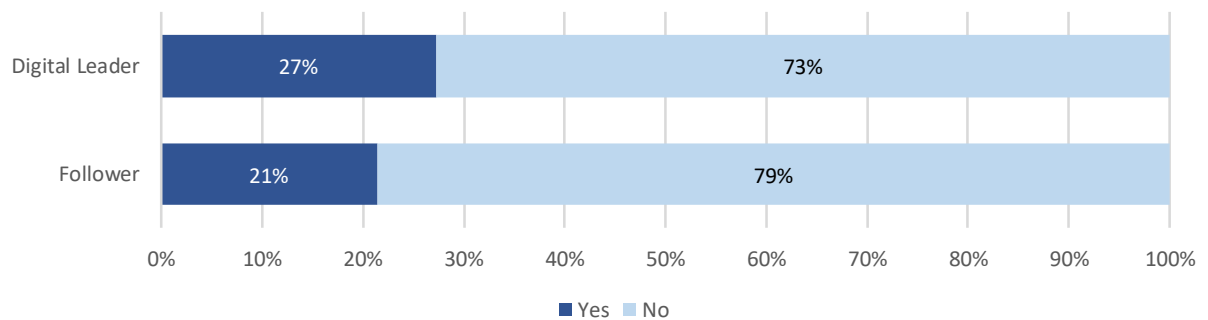


Figure 36: Is the corporation already working on specific projects using blockchain in operation or supporting the business processes? (digital leaders vs. followers) (n=86)

As for corporations that already have some or several blockchain implementations supporting the current business processes, Figure 37 shows that company performance does not lead to a major difference between whether blockchain is implemented or not.

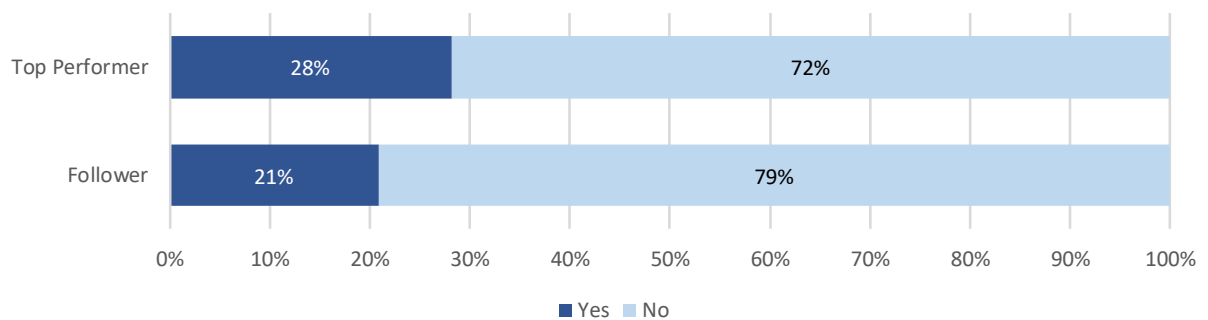


Figure 37: Does the corporation already have some or several blockchain implementations supporting the current business processes? (by company performance) (n=56)

However, one can observe in Figure 38 and Figure 39 that there are significant differences between corporations and whether or not they have implemented blockchain. Digital leaders have around twice as many blockchain activities already implemented that support

current business processes, and among strong innovators, 27 percent state that they have already some or several blockchain implementations to support their current business processes. Among the followers, however, none of the companies implemented anything, and thus 100 percent report that they have no current blockchain implementation projects.

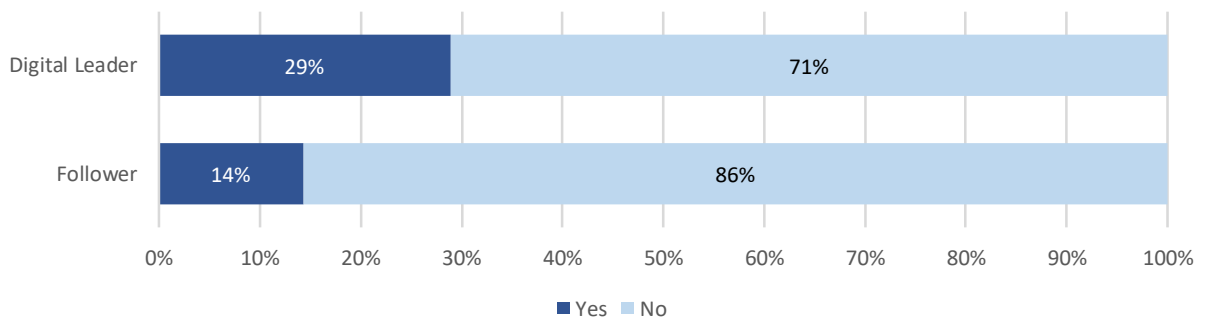


Figure 38: Does the corporation already have some or several blockchain implementations supporting the current business processes? (digital leaders vs. followers) (n=87)

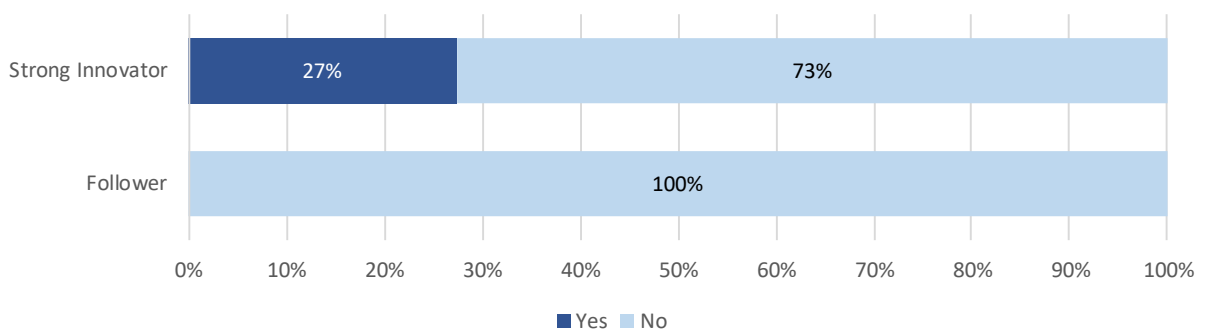


Figure 39: Does the corporation already have some or several blockchain implementations supporting the current business processes? (strong innovators vs. followers) (n=63)

Another interesting observation from this empirical study is whether companies are more inclined to make their first steps towards blockchain alone, or if they consider help. In other words, do companies built their own blockchain solutions or do they source it from providers, the classic “make or buy” question. Given the technical complexity of this new and young technology, it is understandable that the majority of companies outsourced their blockchain projects 64 percent (Figure 40).

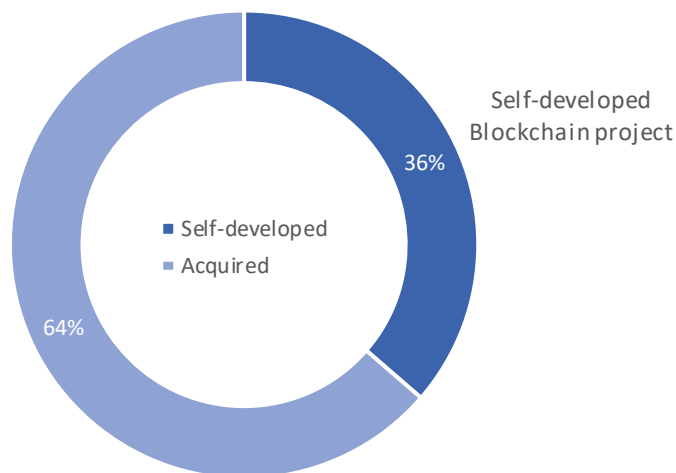


Figure 40: Make or buy blockchain projects? (n=33)

Figure 41 looks at managerial insights of various aspects regarding blockchain technology and its relevance for achieving competitive advantages. The graph depicts similar trends in all four questions that observe the possibilities and limitations of current blockchain solutions for new products and services and in improving existing business processes and the competitor uses of blockchain solutions regarding new products and services and improving existing business processes. The depths of managerial insight in all these topics hover around 11-15 percent (deep insight and very deep insight combined).

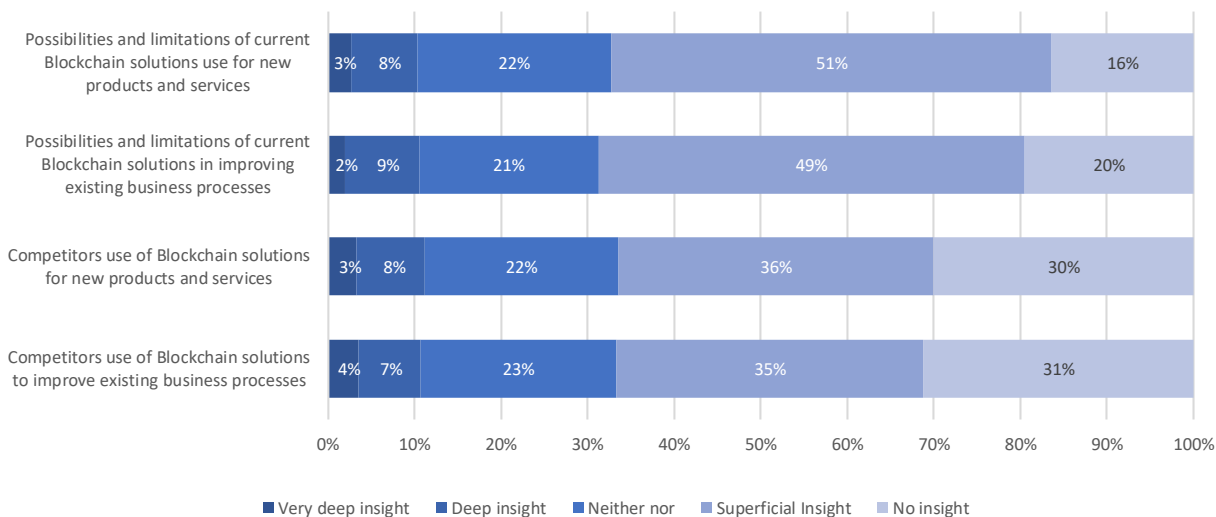


Figure 41: Managerial insights into different aspects of blockchain technology and its competitive relevance (n=446, n=445, n=420, n=420)

Geographic Location of Companies Active in Blockchain

The following map provides a variety of observations of companies and their activity around blockchain-based solutions:

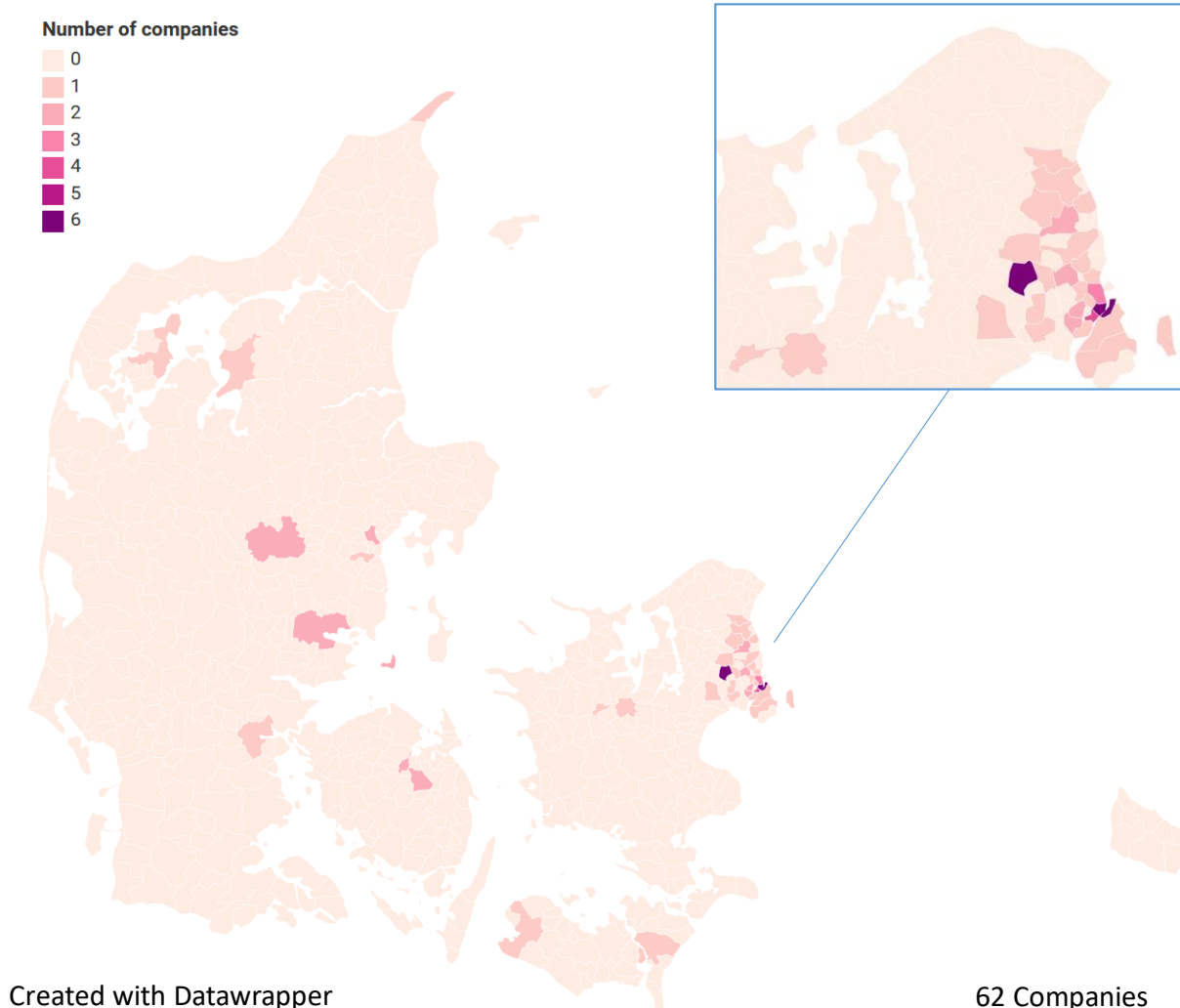


Figure 42: Companies actively pursuing blockchain projects

There are 11 provinces in Denmark (Copenhagen City, Copenhagen Surroundings, North Zealand, Bornholm, East Zealand, West and South Zealand, Funen, South Jutland, West Jutland, East Jutland, North Jutland), which make up the five regions of Denmark, which are Capital Region of Denmark, Region Zealand, Region Southern Denmark, Central Denmark Region, and North Denmark Region. The cities with the four largest populations are Copenhagen, Aarhus, Odense, and Aalborg.

As depicted in Figure 42, there are companies active in blockchain in all regions of Denmark. This map depicts the company density of 62 companies across Denmark which do

some sort of blockchain project and which we could localize. As expected, the highest density of companies active in blockchain are in either Copenhagen City or Copenhagen Surroundings. That said, there is also a higher density of companies that are active in other major cities in Denmark, such as Odense.

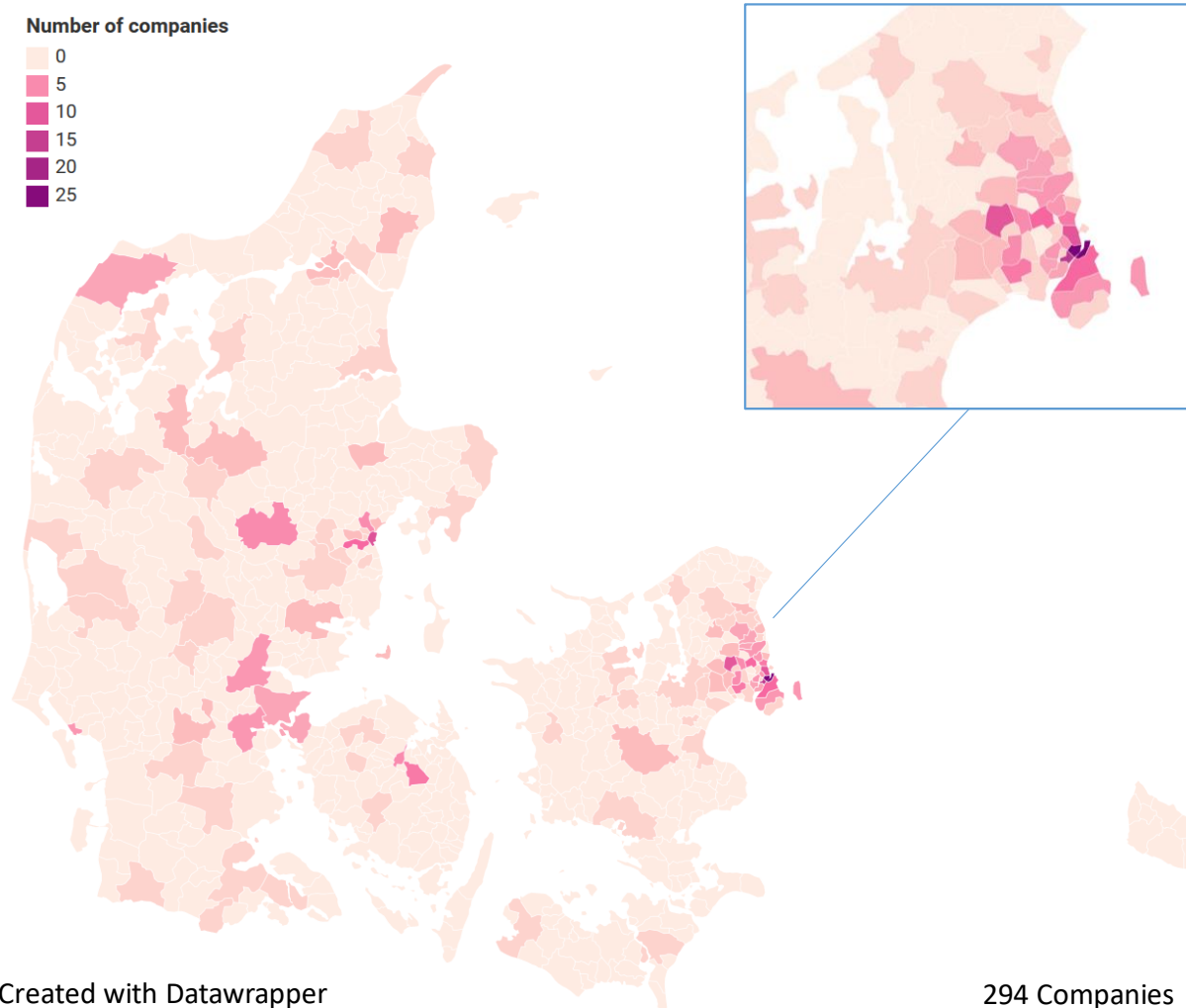


Figure 43: Companies actively working with and investigating blockchain technology

In Figure 43, one can observe the density of how many companies across Denmark are actively working and further investigating blockchain technology solutions. There are 294 companies that were included in this observation. The highest density of companies is in the greater area of Copenhagen, which was as expected. However, one can also observe that there is interest and activity across all over Denmark among companies that are working with or investigating the usefulness of blockchain technology.

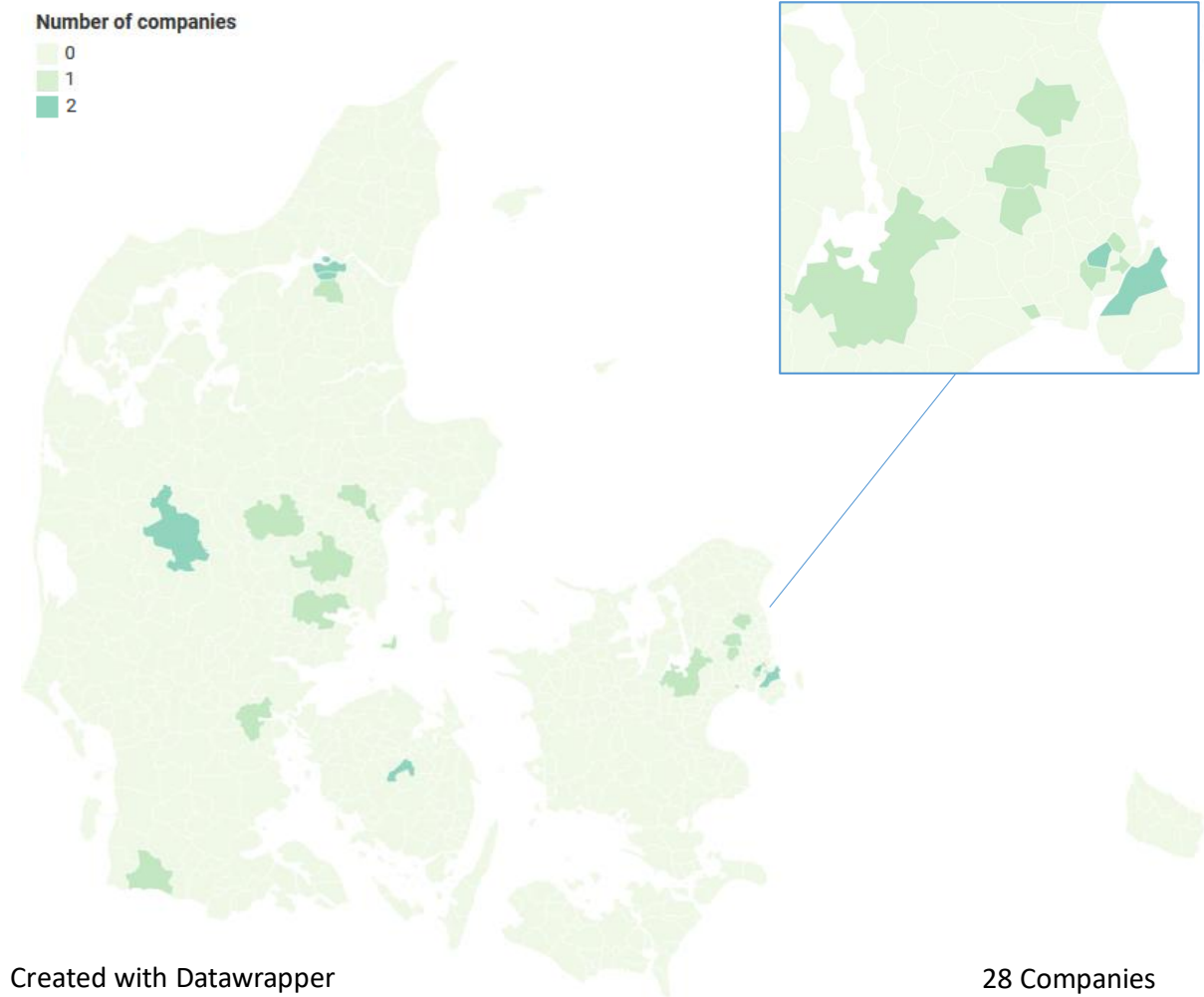


Figure 44: Companies that are not yet active, but are expecting future application of blockchain technology

Figure 44 illustrates which regions of Denmark are not yet as active when it comes to testing and implementing blockchain solutions yet, however, are expecting to do so in the future. Overall, the number of companies depicted per area are much lower than in the previous graphs, with a range of 0 to 2 as the sample size is only 28 companies. With that, the activity around Copenhagen is much lower than previously shown. The areas that have been active in the maps before are still the most active regions. One could interpret this as an indicator for companies that those who are not already actively interested or actively implementing blockchain technologies today are also those who will be late adopters and regard the need for blockchain solutions as less important. However, it needs to be taken into consideration that this is a small sample size of observations, which allow only limited insights.

Potential Use of Blockchain Technology and Specific Applications

This section dives into some of the empirical results that disclosed the potential areas of application of blockchain technologies. As seen in Figure 45, around one third of companies are expecting to apply some kind of blockchain application in the future, which is a really high percentage, given that the technology is still in its infancies and that it is not completely clear where blockchain will make a difference. A third of Danish companies regard blockchain already as a technology of the future.

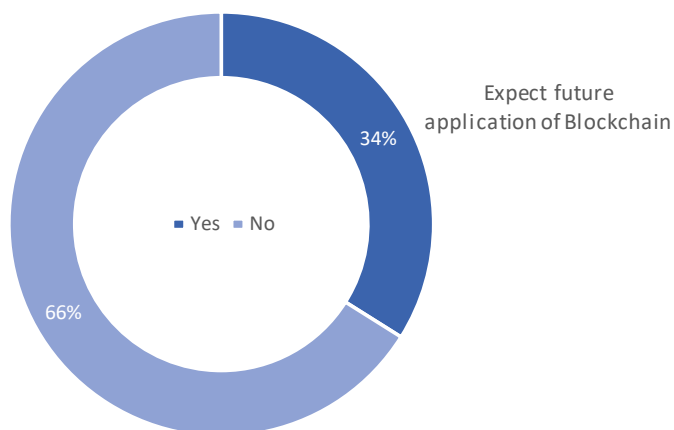


Figure 45: Proportion of companies expecting future application of blockchain (n=224)

Naturally, large companies are able to spend more resources into exploring and investing the potentials of blockchain applications, as following Figure 46 confirms. With start-ups considered as micro-companies, it also makes sense that they are — compared to large or mid-sized companies — frontrunners in the investment into blockchain, as many of those are “blockchain born” or “blockchain native” companies.

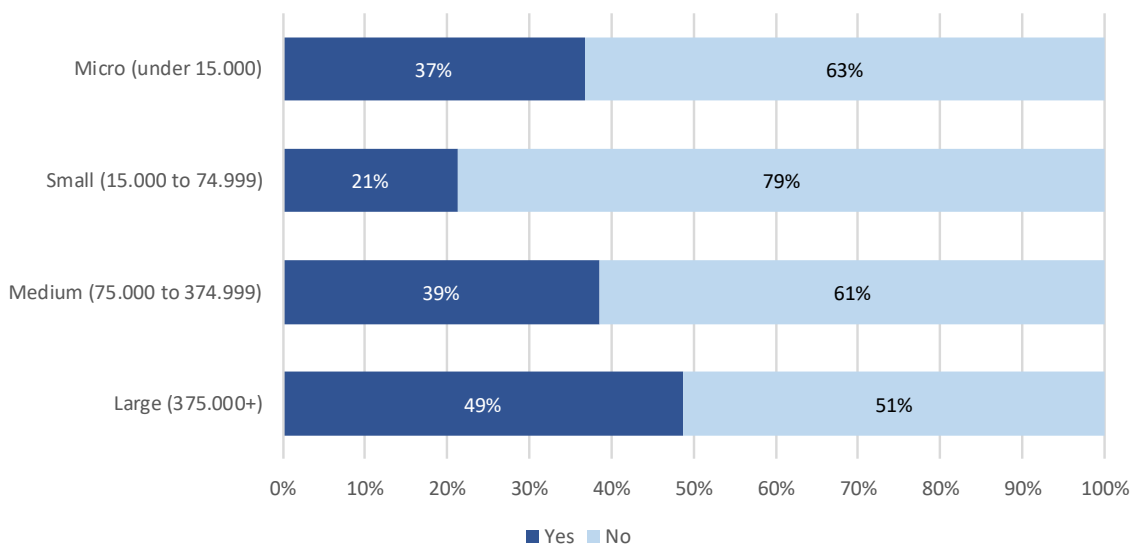


Figure 46: Proportion of companies expecting future application of blockchain (by company size in 1,000.- DKK revenue) (n=220)

Figure 47 considers which industries are expecting future application of blockchain. It illustrates that the finance and insurance industry is leading in adoption, which could be due to the popularity of cryptocurrency and Bitcoin applications.

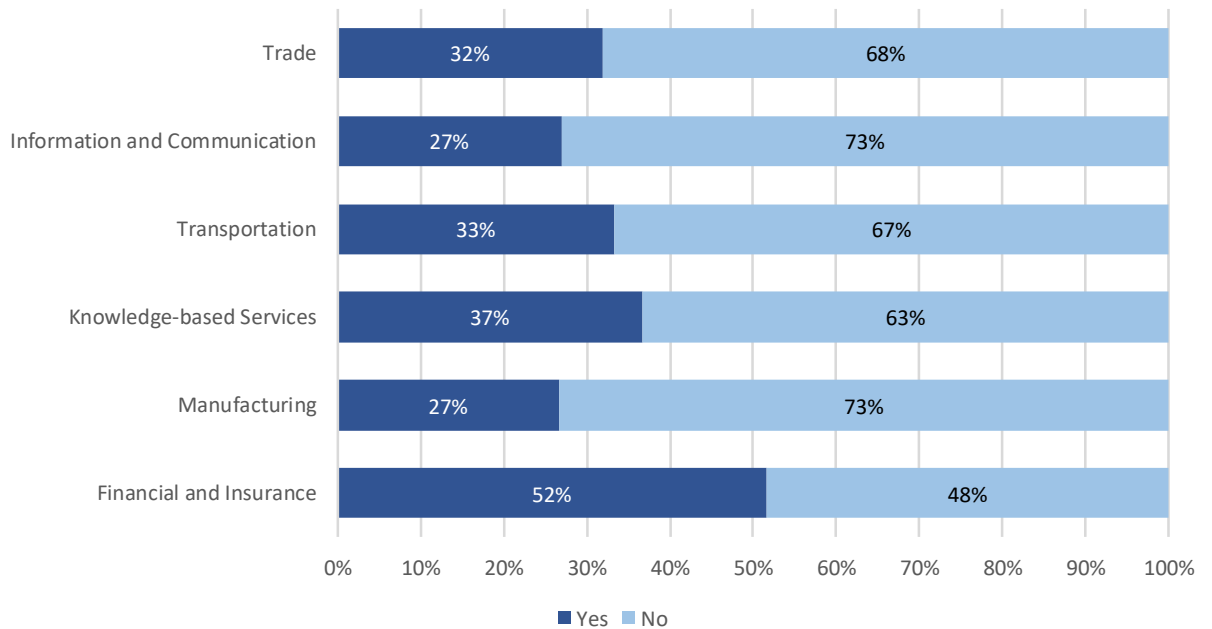


Figure 47: Proportion of companies expecting future application of blockchain (by industry sector) (n=224)

As for observing ambitious firms (top performers, digital leaders, and strong innovators) in Figure 48, Figure 49, and Figure 50, one can see that they all have similar future application expectations. However, for the digital leaders vs. followers, the followers have 11 percent more expectation of future application of blockchain than the digital leaders, which requires further investigation before one can draw any conclusion from that fact.

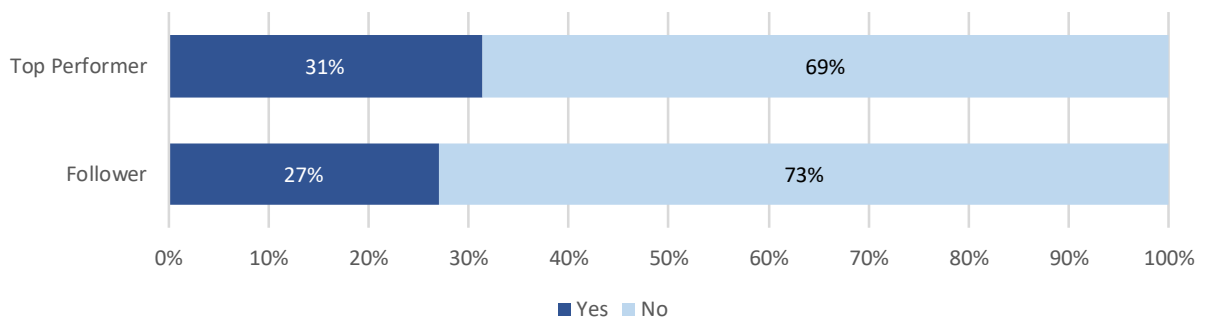


Figure 48: Proportion of companies expecting future application of blockchain (by company performance) (n=115)

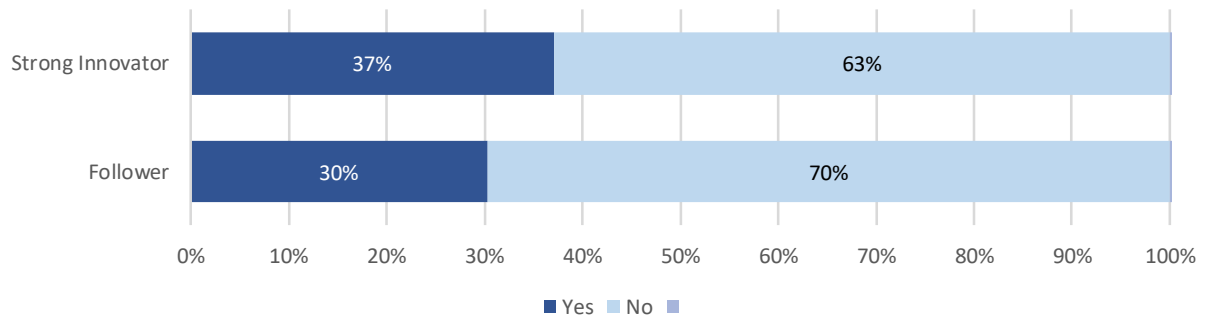


Figure 49: Proportion of companies expecting future application of blockchain (top innovators vs. followers) (n=95)

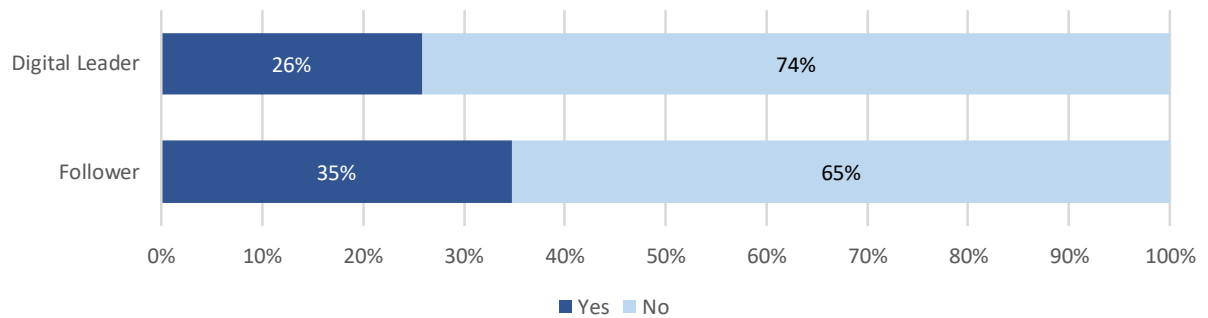


Figure 50: Proportion of companies expecting future application of blockchain (digital leaders vs. followers) (n=150)

Moving on to looking into how many companies and what kind of companies are planning on getting engaged with blockchain and related activities. The survey found that 71 percent are indeed planning on blockchain-related activities (Figure 51).

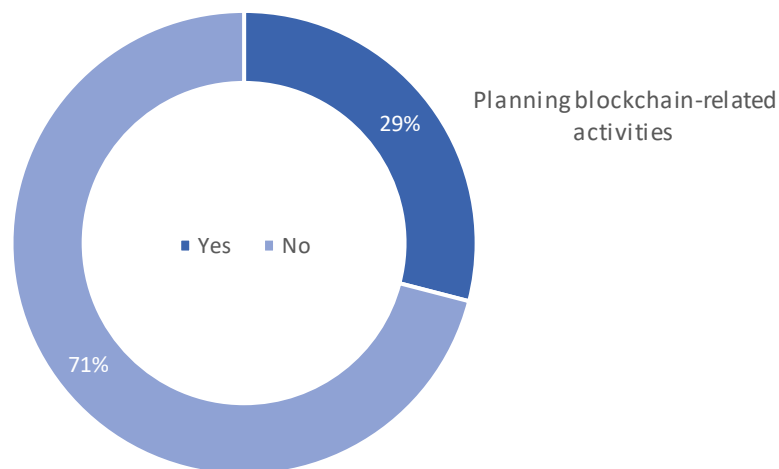


Figure 51: Proportion of companies planning blockchain-related activities (n=124)

Similar to what was observed when looking into which companies were expecting future blockchain applications, Figure 52 shows that large companies and micro companies show the most enthusiasm for planning blockchain-related activities. As mentioned before, this potentially can be explained due to the motivation of start-ups and micro-sized companies on the one hand, as well as the resources that large companies command over. As for observing on an industry level, Figure 53 shows that finance and insurance as well as transportation being the leading industries that are interested in planning blockchain activities.

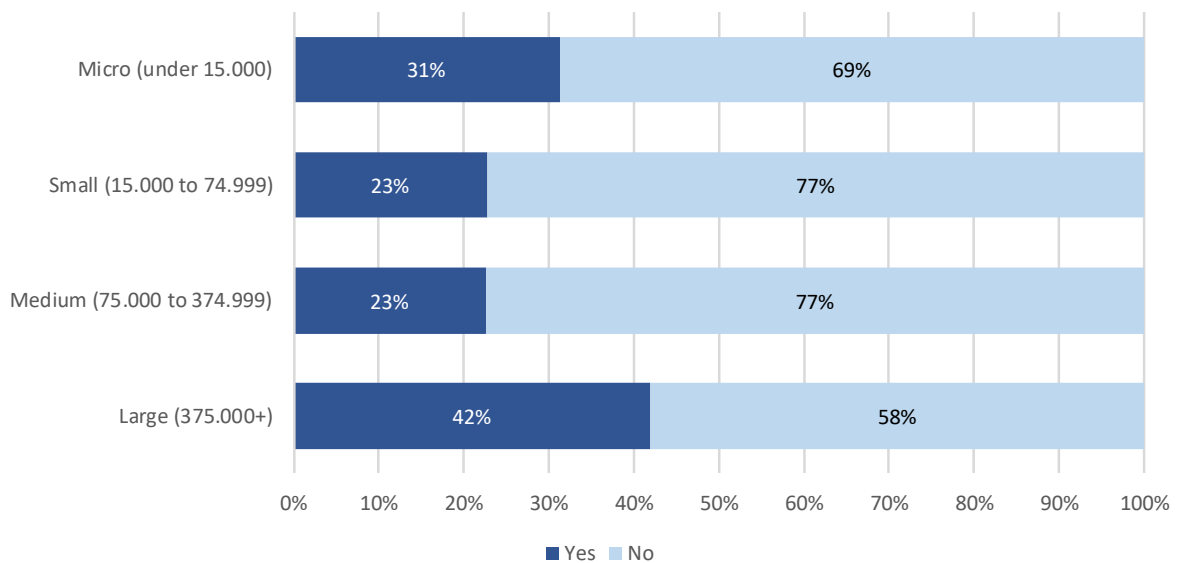


Figure 52: Proportion of companies planning blockchain-related activities (by company size in 1,000.- DKK revenue) (n=122)

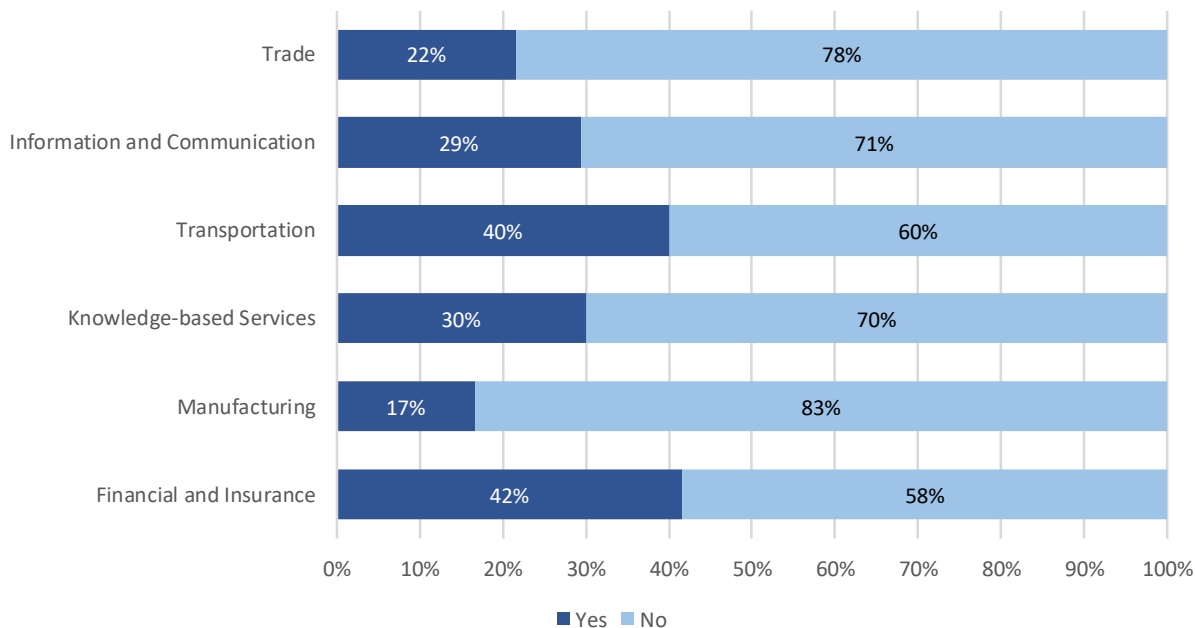


Figure 53: Proportion of companies planning blockchain-related activities (by industry sector) (n=124)

As to be expected, the ambitious corporations that fall into the top performers, strong innovators and digital leaders categories are indeed leading in their plans on blockchain-related activities in Figure 54, Figure 55, and Figure 56. The strong innovators are planning almost three times as much blockchain-related activities as the followers. However, largely across all types of players there are high majorities that have no plans at all (62-91 percent).

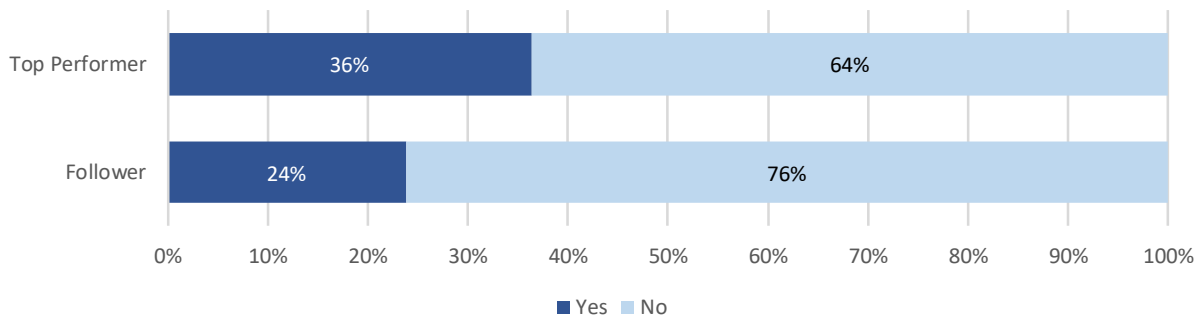


Figure 54: Proportion of companies planning blockchain-related activities (by company performance) (n=54)

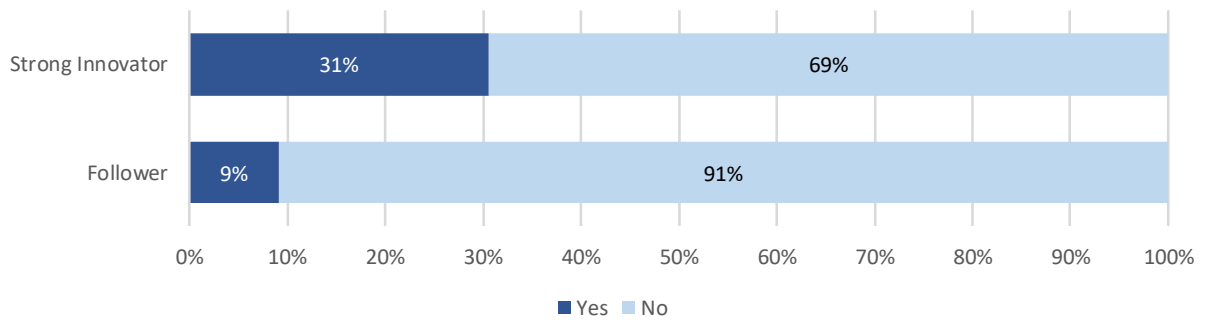


Figure 55: Proportion of companies planning blockchain-related activities (strong innovators vs. followers) (n=60)

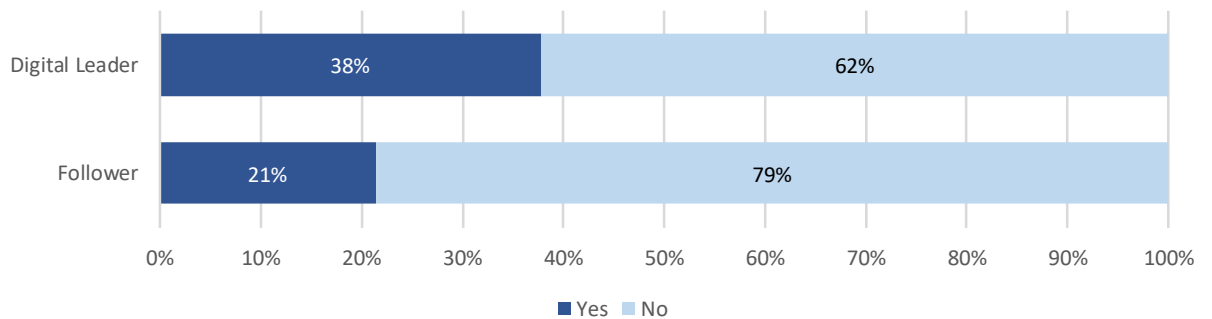


Figure 56: Proportion of companies planning blockchain-related activities (digital leaders vs. followers) (n=87)

Lastly, the empirical study looked at specific use cases of blockchain and the subsequent improvement of business processes, the transparency and security in supply chains, and payment processes or financial solutions. Regarding the effectiveness of business processes and transparency and security of supply chains, a majority with over 50 percent reported at least some extent of improvement for each of the cases. Regarding the improvement of payment processes or financial solutions, 45 percent also reported having at least some extent of improvement, as seen Figure 57. Thirty-five percent of the companies also consider others use cases than the three mentioned above.

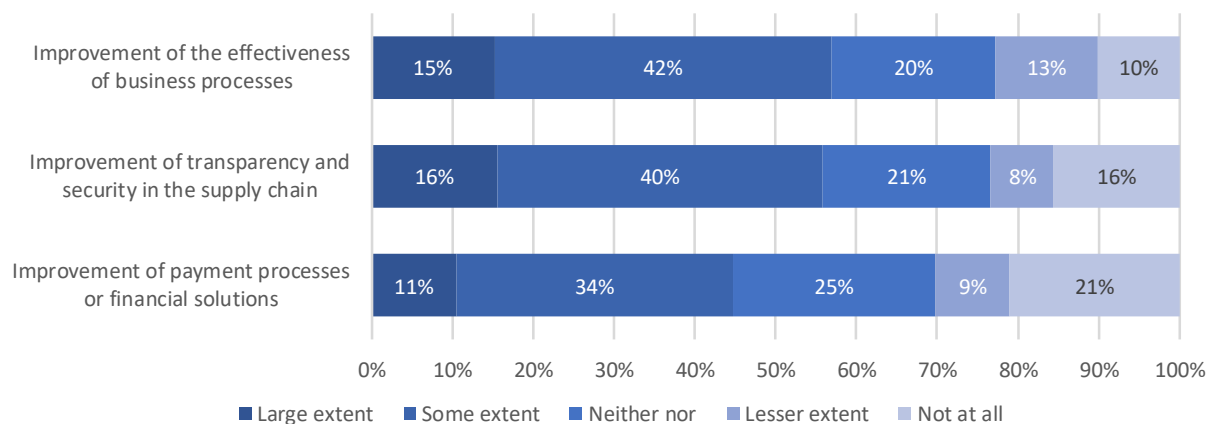


Figure 57: Blockchain use cases currently considered (n=79, n=77, n=76)

Potential Challenges of Applying Blockchain Technologies

Next, we investigate which specific challenges companies in our sample may see when it comes to implement blockchain technologies today, and which might constrain a further or faster adoption in Denmark. Again, we are first looking at the general picture over all companies, before analyzing the specifics of different sub-groups of companies.

Figure 58 illustrates that a lack of standardized solutions and of experts are seen as the most important hurdles at the moment. This of course is not that surprising, given that blockchain is still a relatively new technology. Standardization activities and more training and education programs that educate blockchain experts seem to be required.

On the other hand, the digital innovation climate in Denmark is not seen as hindering factor for blockchain adoption, as it is internationally often reported by companies outside Denmark. In other words, the digital innovation climate is helping companies to roll out blockchain initiatives. When we particularly asked whether companies were waiting for a “blockchain lighthouse project” implemented in the public sector, only 6 percent of the companies said they would do so. This is an indication that Danish companies do not wait for the public sector to lead the innovation process by large projects to break the ice, as it is considered to be necessary in other countries.

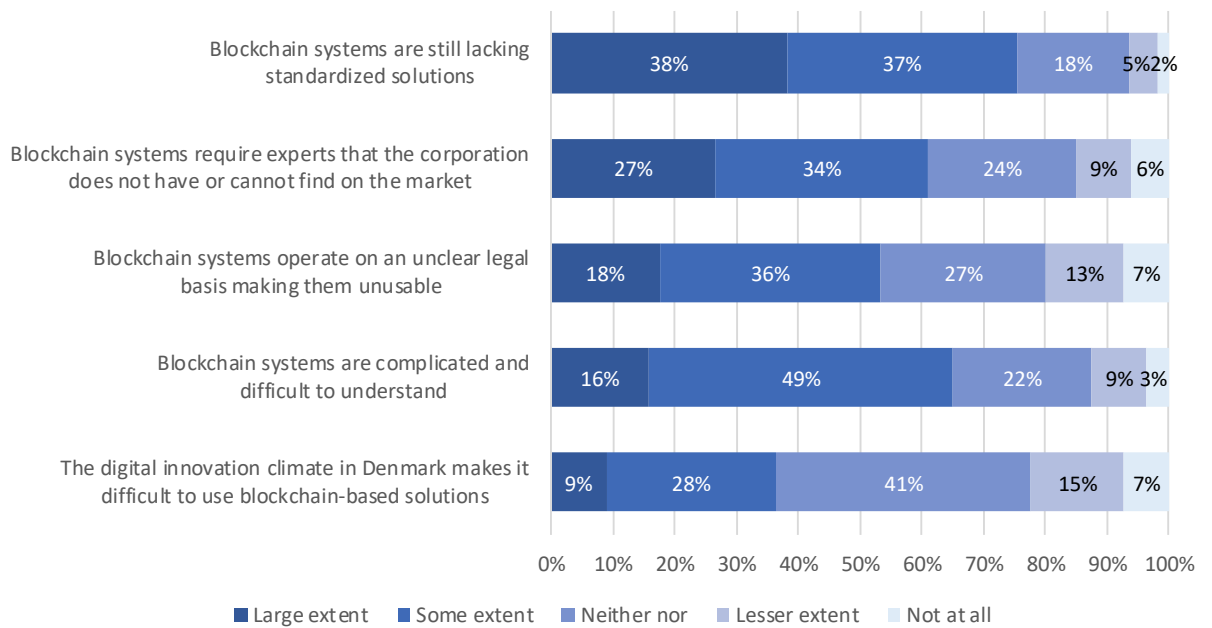


Figure 58: Challenges for blockchain adoption (n=280, n=293, n=245, n=373, n=247)

Next, we will analyze whether the perceived challenges differ across the different types of companies in the sample.

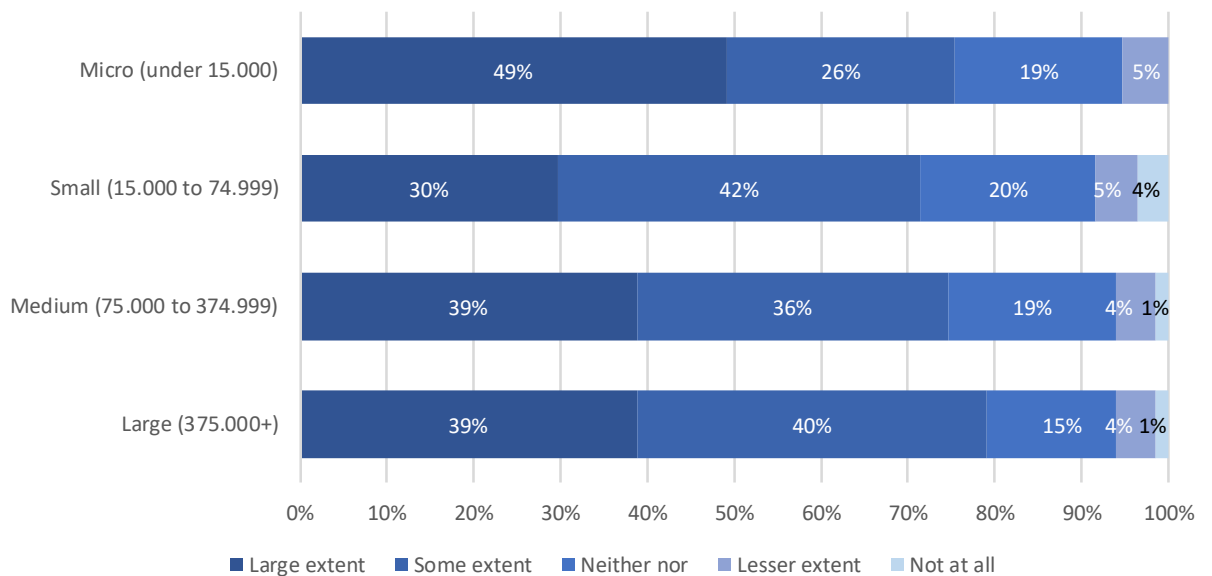


Figure 59: To which extent are blockchain systems still lacking standardized solutions? (by company size in 1,000.- DKK revenue) (n=275)

Regarding the lack of standardized solutions there is no very strong difference between companies of different size (Figure 59) and from different sectors (Figure 60). Only small

companies as well as companies from the trade and transportation sector seem to be a bit less concerned about the lack of already existing standards.

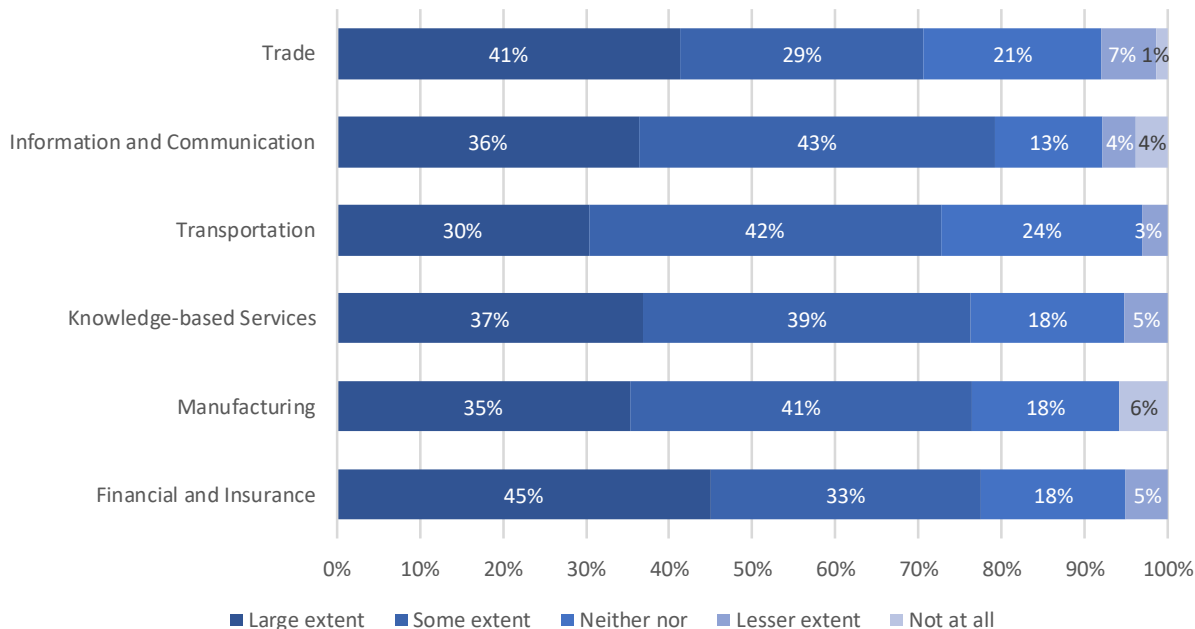


Figure 60: To which extent are blockchain systems still lacking standardized solutions? (by industry sector) (n=280)

For analyzing the perceived blockchain adoption challenges, we introduce another grouping of our data sample, where we differentiated in companies with high and low knowledge about blockchain. For that, we compare companies with high knowledge on blockchain (based on their self-assessment, see Figure 21) with companies that have reported to possess little knowledge.

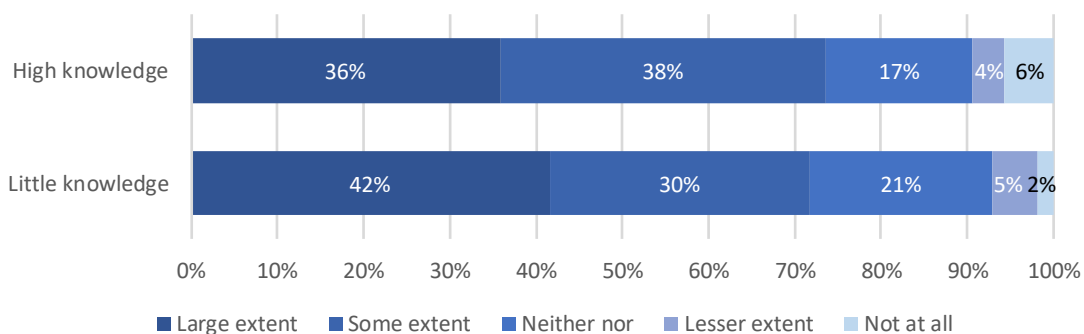


Figure 61: To which extent are blockchain systems still lacking standardized solutions? (by self-reported blockchain knowledge) (n=280)

It is interesting to note that companies performing economically well (Figure 33), as well strong innovators (Figure 63), and digital leaders (Figure 64), all see a lack of standardized

solution as a significantly higher challenge than their respective counter-groups. Standards seem to be of importance for these three groups.

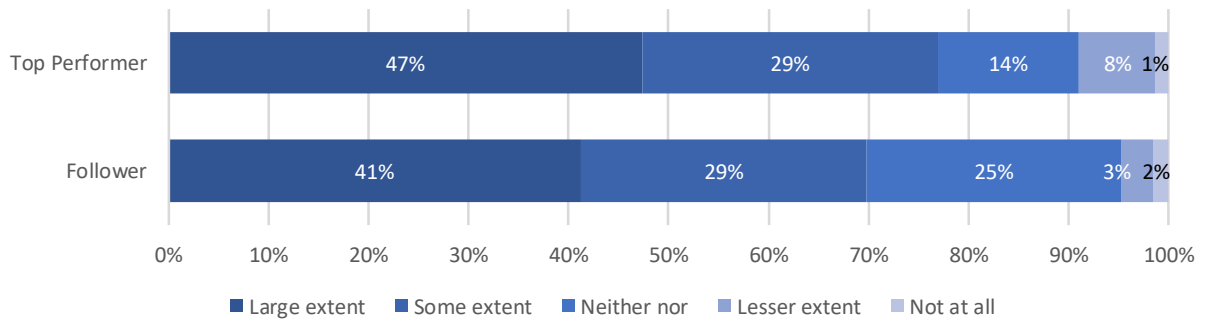


Figure 62: To which extent are blockchain systems still lacking standardized solutions? (by company performance) (n=141)

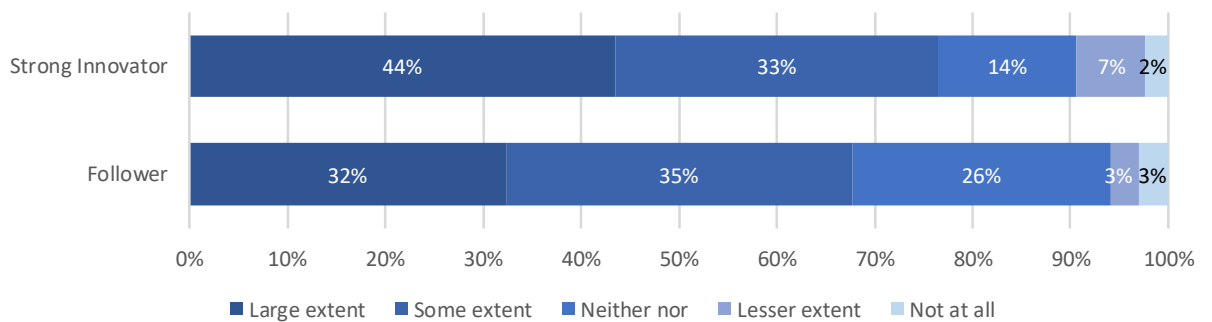


Figure 63: To which extent are blockchain systems still lacking standardized solutions? (strong innovators vs. followers) (n=119)

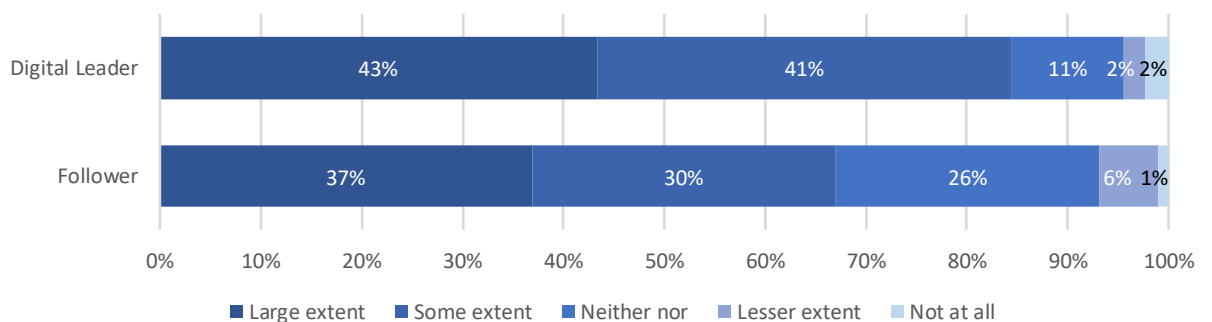


Figure 64: To which extent are blockchain systems still lacking standardized solutions? (digital leaders vs. followers) (n=193)

The next adoption barrier we analyze regarding different groups is the shortage of blockchain-experts on the labor market. Again, we do not see much variance between companies of different sizes (Figure 65).

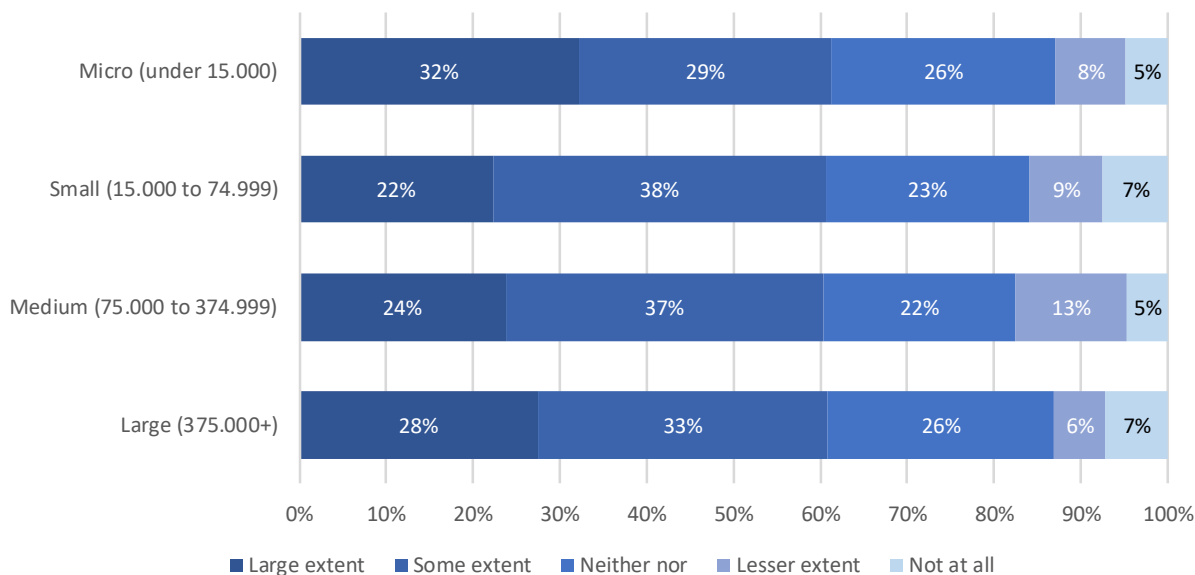


Figure 65: To which extent do blockchain systems require experts that the corporation does not have or cannot find on the market? (by company size) (n=288)

The lack of experts seems to be particularly challenging for the transportation industry, as well as for the financial services and insurance industries (Figure 66). It is also interesting to note that manufacturers perceive this challenge to be significantly lower compared to the other industries.

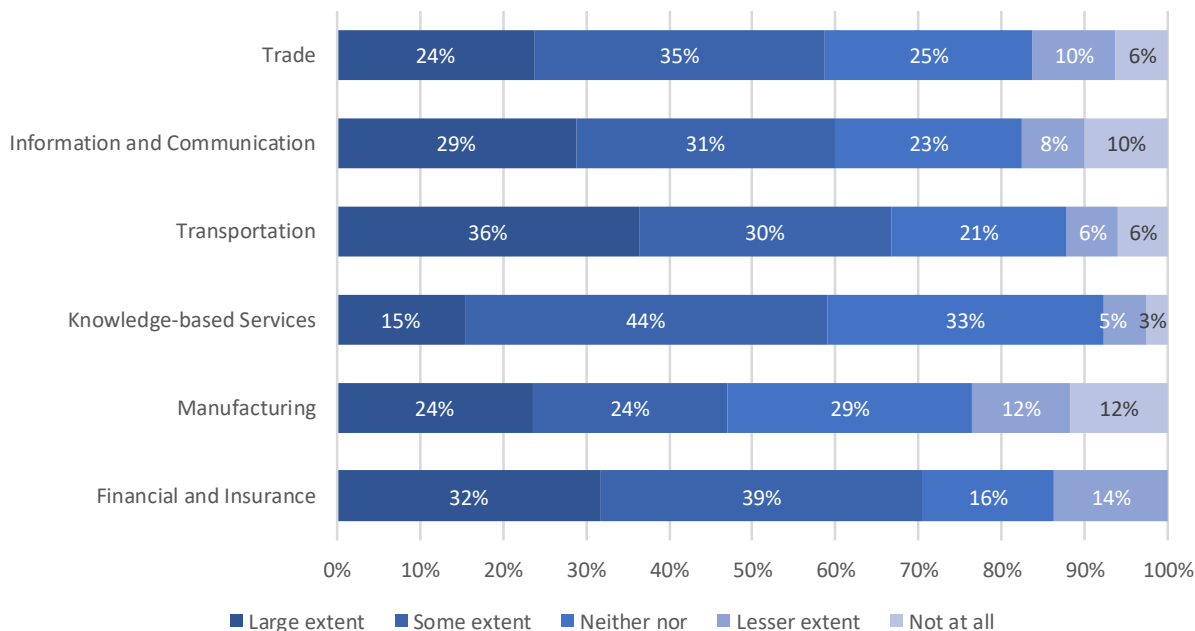


Figure 66: To which extent do blockchain systems require experts that the corporation does not have or cannot find on the market? (by industry sector) (n=293)

Companies with high knowledge apparently were more successful in finding blockchain experts compared to companies with little knowledge (Figure 67). But even in this group it remains a relevant challenge, with the majority of companies mentioning this to be a bottleneck at least to some extent.

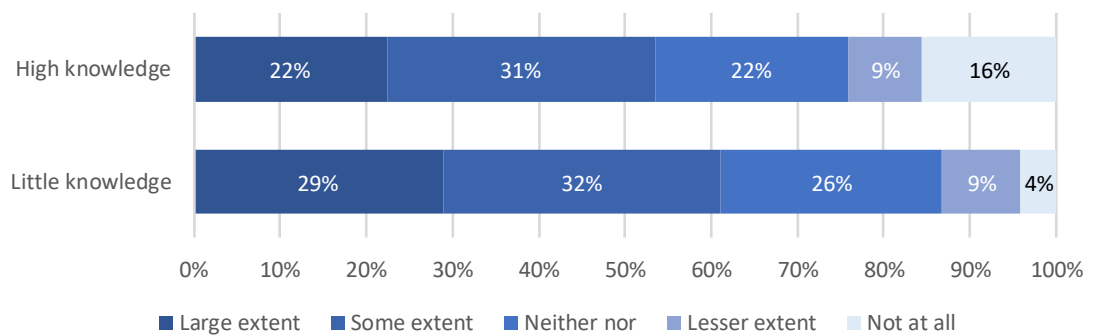


Figure 67: To which extent do blockchain systems require experts that the corporation does not have or cannot find on the market? (by self-reported blockchain knowledge) (n=293)

Figure 68 illustrates that even the well performing, top companies, perceive it as a significant problem that the required experts cannot be found or higher (59 percent). The challenge is only slightly more problematic for the follower companies (65 percent).

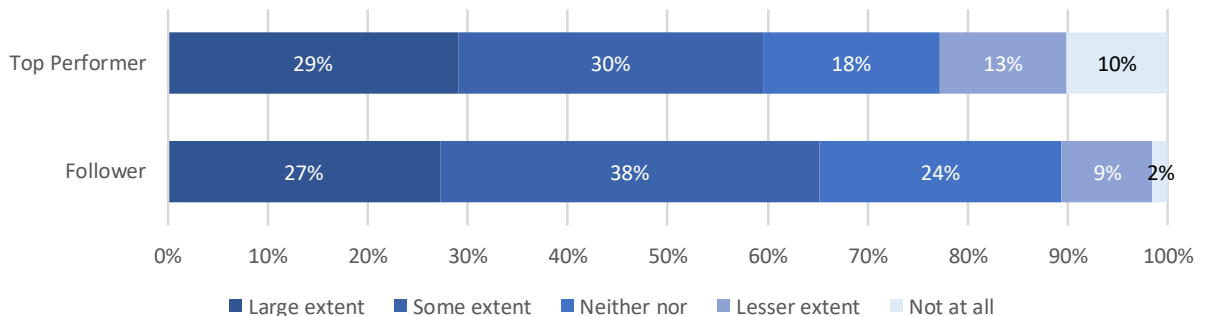


Figure 68: To which extent do blockchain systems require experts that the corporation does not have or cannot find on the market? (by company performance) (n=145)

When comparing companies based on their innovation or digital leadership, then the results are becoming inconclusive (Figure 69 and Figure 70). It is not possible to draw a clear conclusion here except that the lack of experts seems to be a challenge for all these groups of companies.

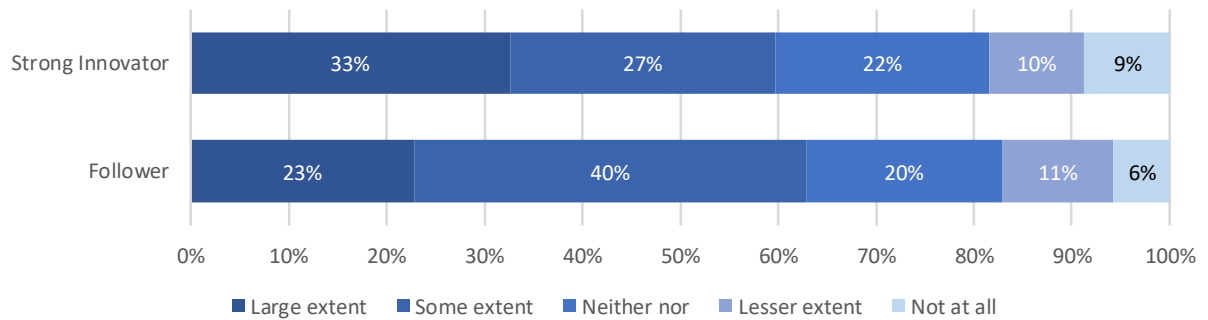


Figure 69: To which extent do blockchain systems require experts that the corporation does not have or cannot find on the market? (strong innovators vs. followers) (n=127)

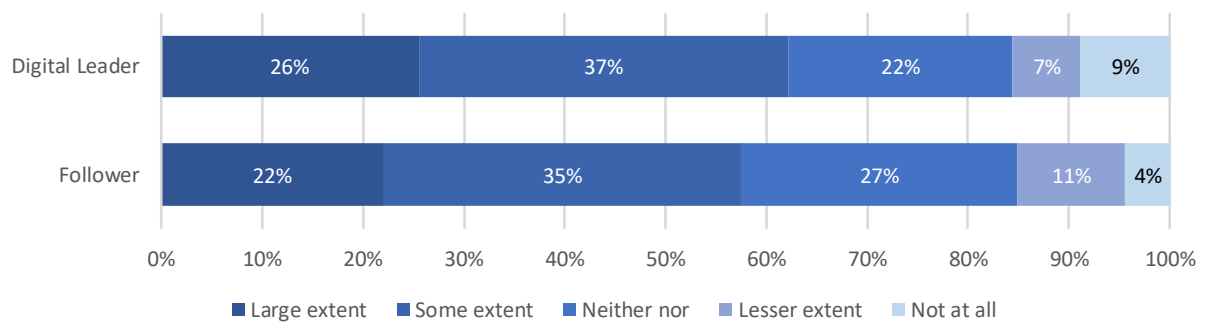


Figure 70: To which extent do blockchain systems require experts that the corporation does not have or cannot find on the market? (digital leaders vs. followers) (n=203)

The notion that blockchain systems are operating on an unclear legal basis seems to be of lesser concern for large companies (Figure 71). A reason could be that these companies can afford or even directly employ the required legal experts. However, to foster blockchain adoption especially among smaller companies, this open issue need to be addressed.

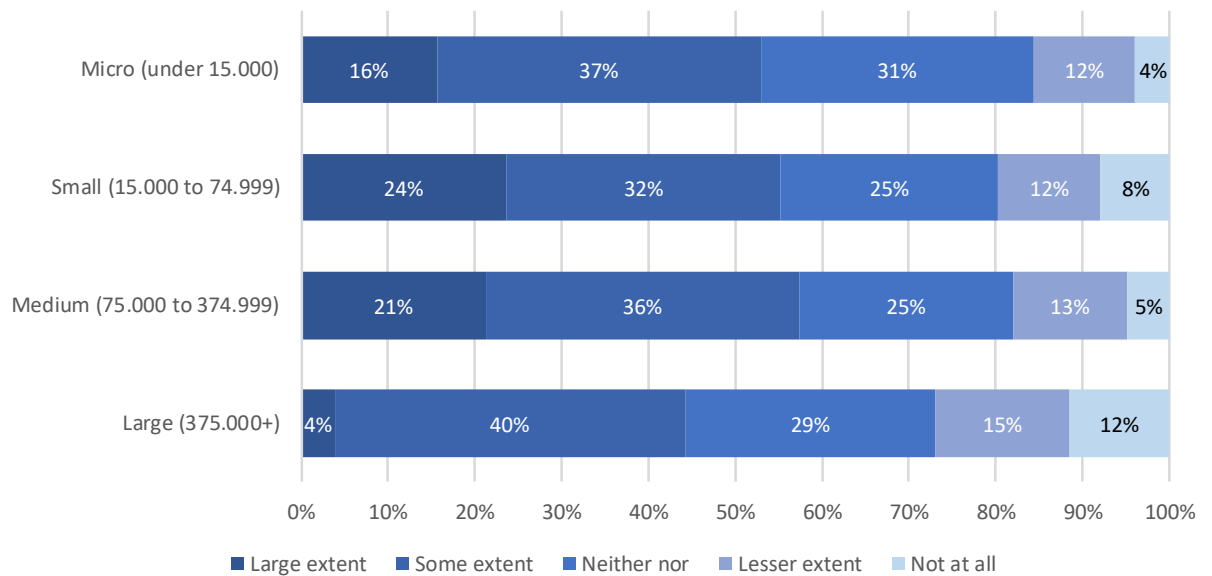


Figure 71; To which extent do blockchain systems operate on an unclear legal basis making them unusable? (by company size in 1,000.- DKK revenue) (n=240)

Comparing different industry sectors does not really give a clear picture (Figure 72). Over all industry sectors, at least 50 percent of the companies see the unclear legal basis at least to some extent as problematic, but no sector seems to require special attention. The trade as well as the financial and insurance industries stand out a little bit.

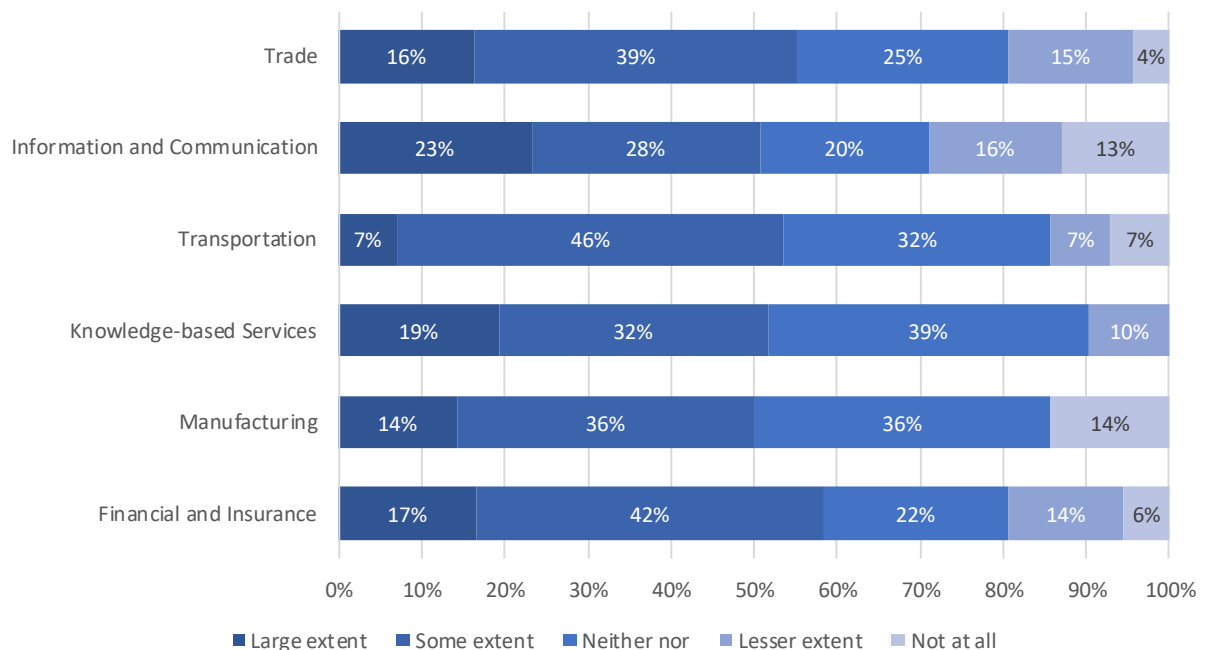


Figure 72: To which extent do blockchain systems operate on an unclear legal basis making them unusable? (by industry sector) (n=245)

As could be expected, companies that are more knowledgeable about blockchain do not see an uncertain or missing legal framework as such a big problem as others, as they have already concerned themselves more with the topic (Figure 73). However, even 17 percent of these companies still see it as a challenge to a large extent and together over 40 percent at least to some extent. Thus, approaching this topic could certainly foster the adoption of blockchain.

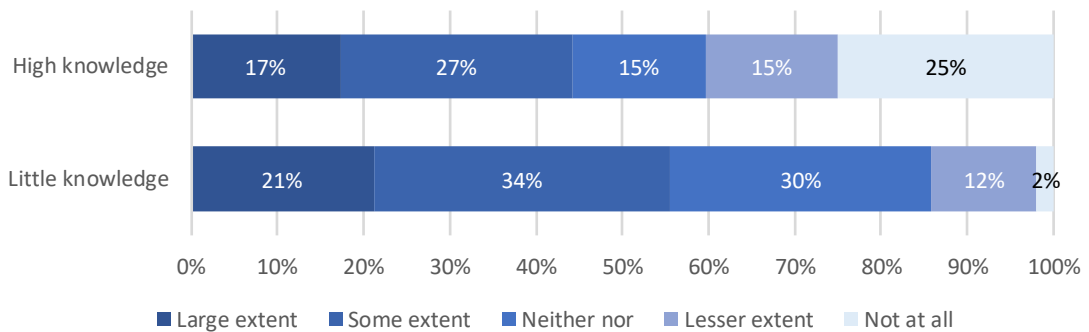


Figure 73: To which extent do blockchain systems operate on an unclear legal basis making them unusable? (by self-reported blockchain knowledge) (n=245)

What comes out as a surprise is that economic top performers (Figure 74), as well as strong innovators (Figure 75), and digital leaders (Figure 76) all see the legal basis as a stronger challenge as their follower-groups. This could be due to the fact that they have spent more time on the problem and are fully aware of the complexity, or that the followers bet upon the fact that once they are adopting blockchain at a later point, the legal issues will be solved.

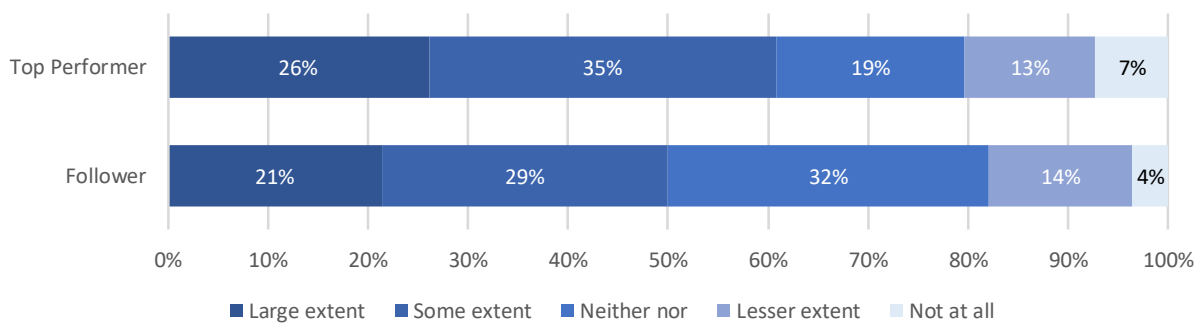


Figure 74: To which extent do blockchain systems operate on an unclear legal basis making them unusable? (by company performance) (n=125)

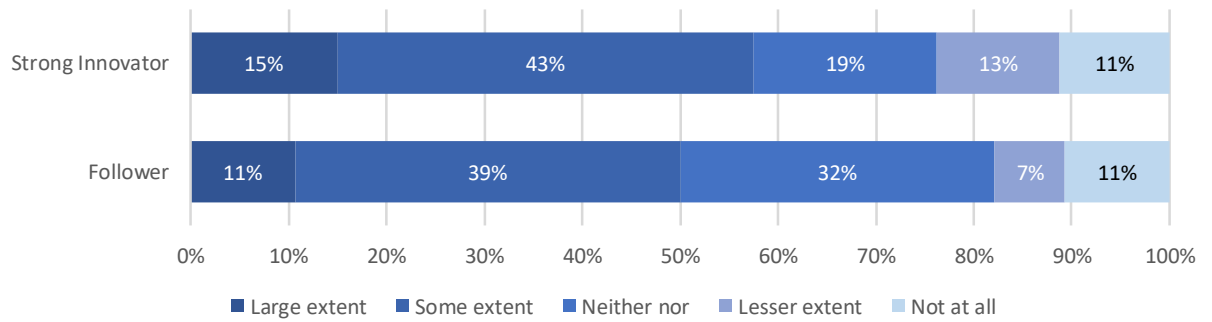


Figure 75: To which extent do blockchain systems operate on an unclear legal basis making them unusable? (strong innovators vs. followers) (n=108)

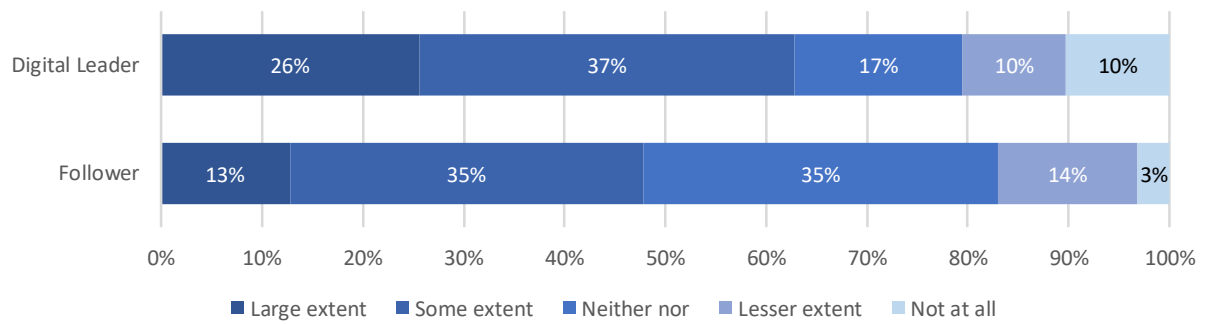


Figure 76: To which extent do blockchain systems operate on an unclear legal basis making them unusable? (digital leaders vs. followers) (n=172)

Blockchain systems are complicated and difficult to understand, which is a challenge for micro to large companies alike (Figure 77). While there is some variance, it is difficult to draw a clear conclusion.

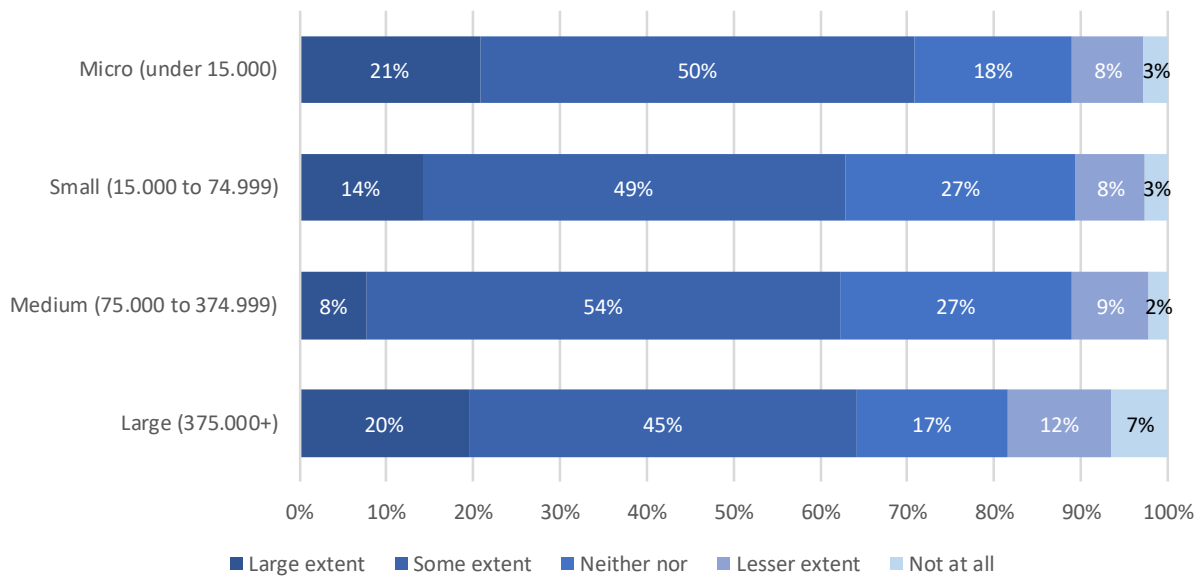


Figure 77: To which extent are blockchain systems complicated and difficult to understand? (by company size in 1,000.- DKK revenue) (n=367)

Between the different sectors, the knowledge-based services sectors as well as financial services and insurance industry stand out when it comes to the assessment of complications arising from the complexity of blockchain technologies. Those companies seem to regard the technological complexity as a bigger problem than the others (Figure 78).

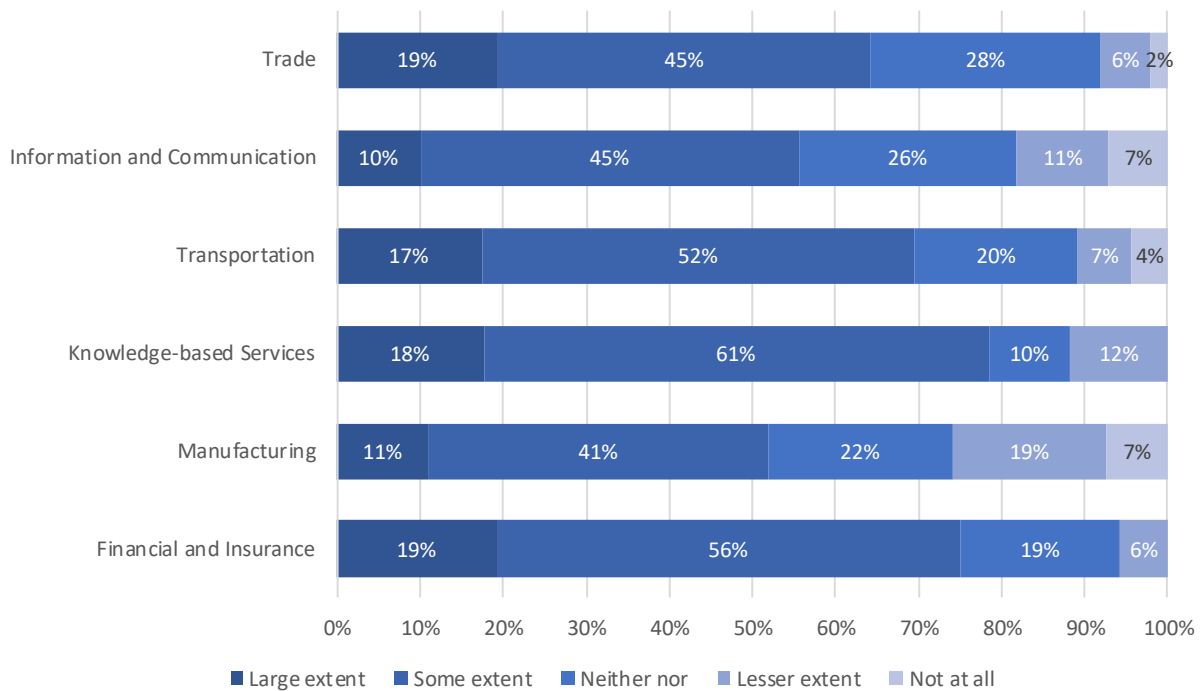


Figure 78: To which extent are blockchain systems complicated and difficult to understand? (by industry sector) (n=373)

Again, it is not that surprising that companies with a higher knowledge see blockchain as less complicated and difficult to understand compared to companies with lower knowledge (Figure 79).

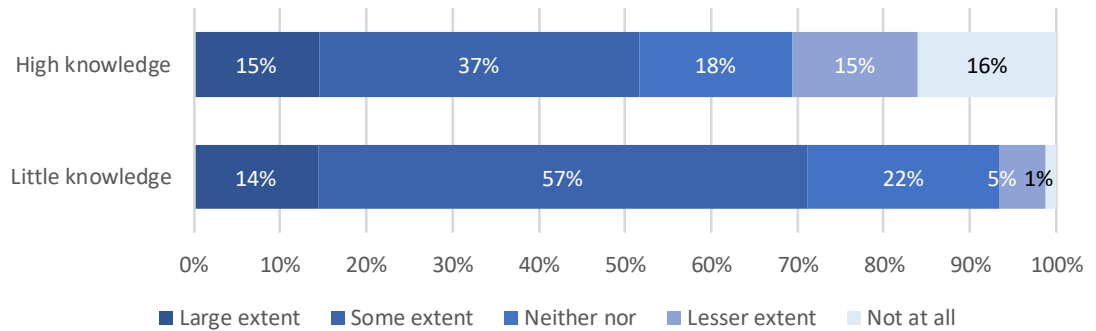


Figure 79: To which extent are blockchain systems complicated and difficult to understand? (by self-reported blockchain knowledge) (n=373)

The picture regarding top performers, strong innovators, digital leaders and their followers is less clear (Figure 80, Figure 81, and Figure 82).

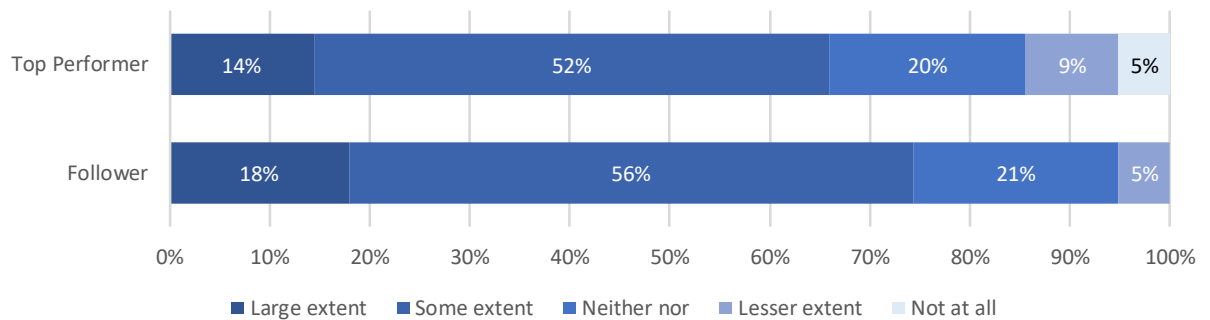


Figure 80: To which extent are blockchain systems complicated and difficult to understand? (by company performance) (n=175)

Economic top performers seem to have less of a problem with the complexity of the technology. The difference between innovative as well as digital leading companies and their followers is, however, inconclusive.

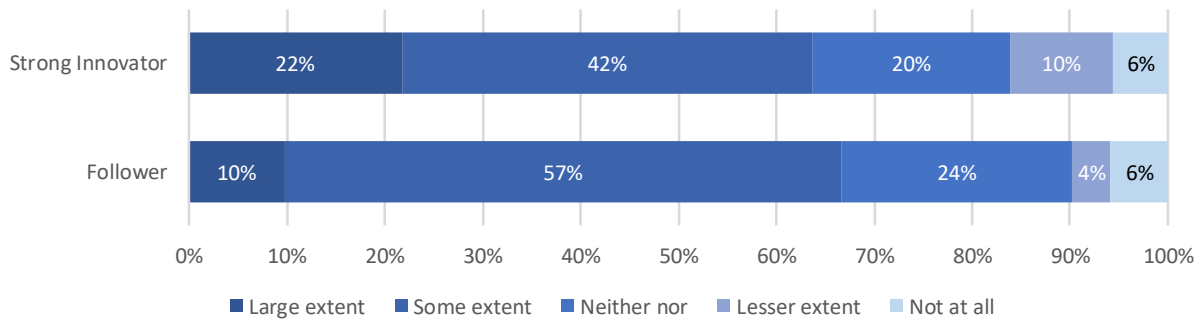


Figure 81: To which extent are blockchain systems complicated and difficult to understand? (strong innovators vs. followers) (n=175)

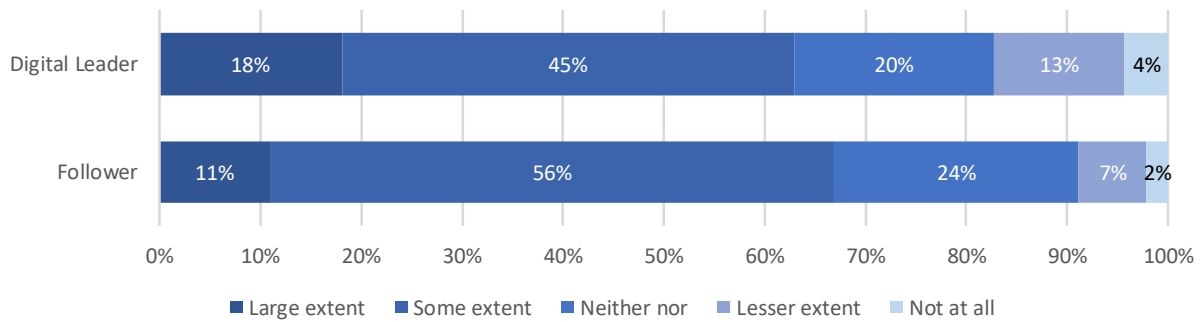


Figure 82: To which extent are blockchain systems complicated and difficult to understand? (digital leaders vs. followers) (n=252)

Regarding the innovation climate in Denmark, smaller companies are perceiving the climate as less fortunate in contrast to larger companies (Figure 82). In other words, if the aim is to improve the blockchain adoption particularly among small and mid-sized companies, one would have to analyze deeper which aspects of the innovation climate in Denmark are especially perceived as hindering factors when it comes to blockchain.

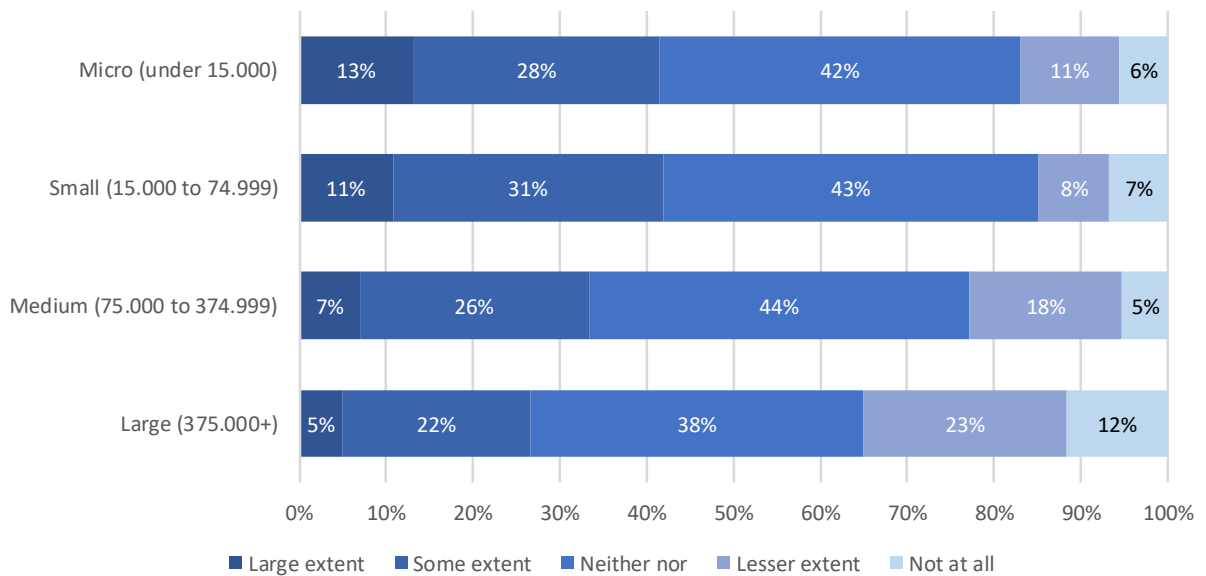


Figure 83: To which extent does the digital innovation climate in Denmark make it difficult to use blockchain-based solutions? (by company size in 1,000.- DKK revenue) (n=244)

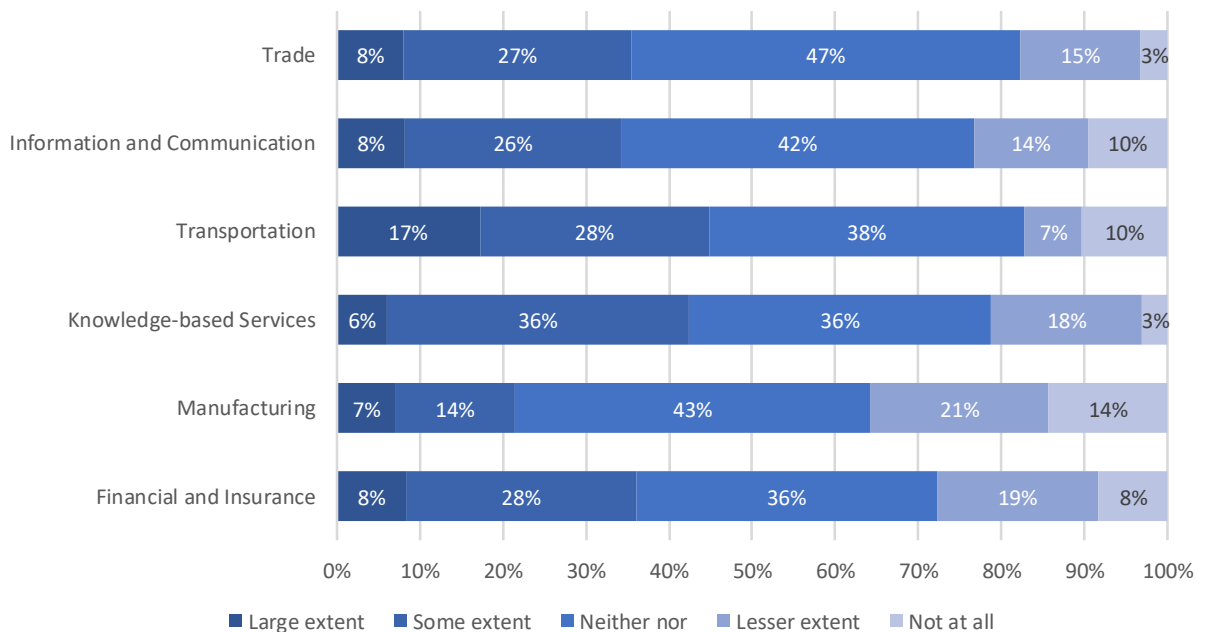


Figure 84: To which extent does the digital innovation climate in Denmark make it difficult to use blockchain-based solutions? (by industry sector) (n=247)

The transportation industry particularly expresses the impression that the digital innovation climate in Denmark makes it difficult to use blockchain-based solutions (Figure 83). This again comes a bit as a surprise, as Denmark has some of the globally leading blockchain initiatives in transportation. An explanation could be again that those who intensely work on solving challenges around new processes design for blockchain solutions and thus are

more mature are also those who know best about all the challenges and problems, which may lead to a negativity effect, where the challenges are over-emphasized.

Companies with higher knowledge about blockchain (Figure 85) and which have a better economic performance than others (Figure 86) see the digital innovation climate in Denmark more skeptical when it comes to blockchain implementation compared to their counter-groups.

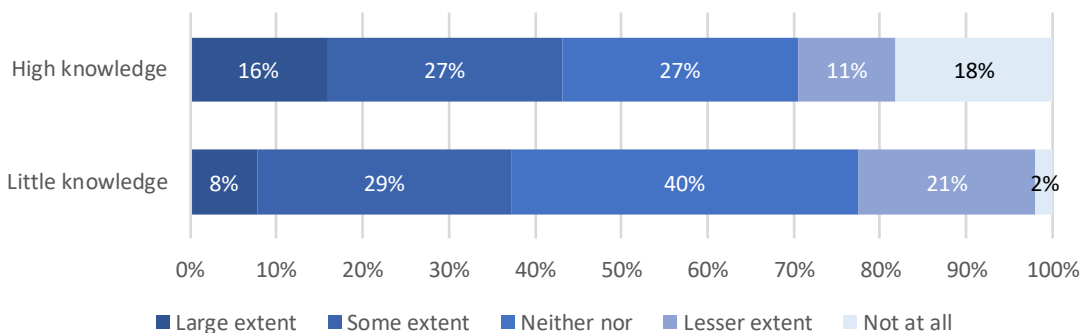


Figure 85: To which extent does the digital innovation climate in Denmark make it difficult to use blockchain-based solutions? (by self-reported blockchain knowledge) (n=247)

There is, however, also a significant group of companies with high knowledge that see absolutely no problem with the digital innovation climate in Denmark regarding blockchain.

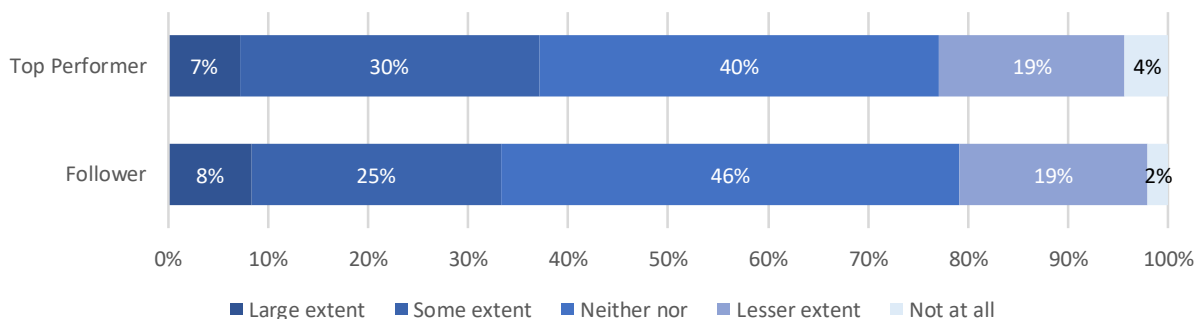


Figure 86: To which extent does the digital innovation climate in Denmark make it difficult to use blockchain-based solutions? (by company performance) (n=118)

The results regarding innovation and digital leadership are even more inconclusive as both leading groups score higher on both ends of the spectrum (Figure 87 and Figure 88).

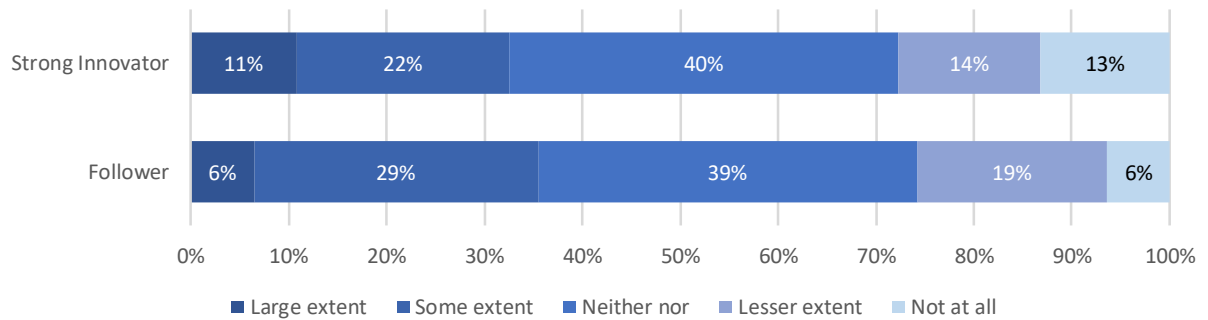


Figure 87: To which extent does the digital innovation climate in Denmark make it difficult to use blockchain-based solutions? (strong innovators vs. followers) (n=114)

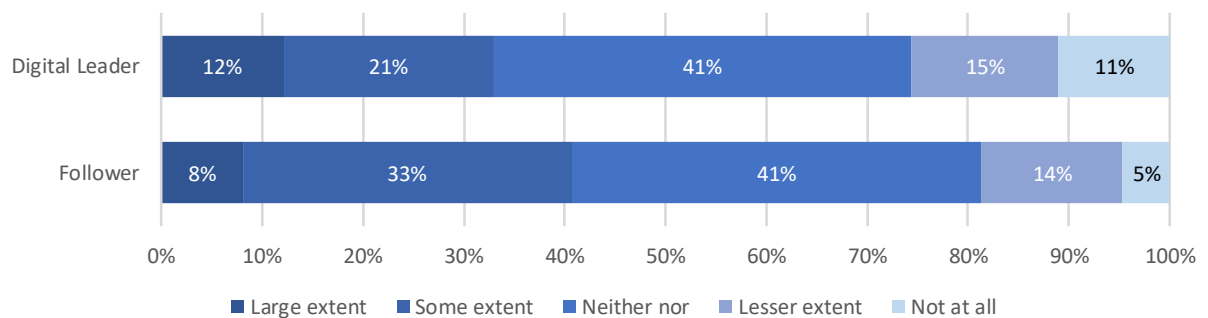


Figure 88: To which extent does the digital innovation climate in Denmark make it difficult to use blockchain-based solutions? (digital leaders vs. followers) (n=168)

Potential and Future Effects of Blockchain

After this study analyzed the drivers and inhibitors of a successful blockchain assimilation in the different industries and for different company sizes, in the following, we will look into to the perceived potentials of blockchain technologies and its future impact on the analyzed industries. Thus, we are interested now how companies use blockchain to stay competitive, and how they think blockchain is going to affect and transform the industries they are operating in.

As Figure 89 illustrates, the largest share of companies that expects an influence of blockchain-based innovations does so with regards to their own corporation's industry sector. Almost half of all companies surveyed (48 percent) believe that their industry will be affected by blockchain in the future.

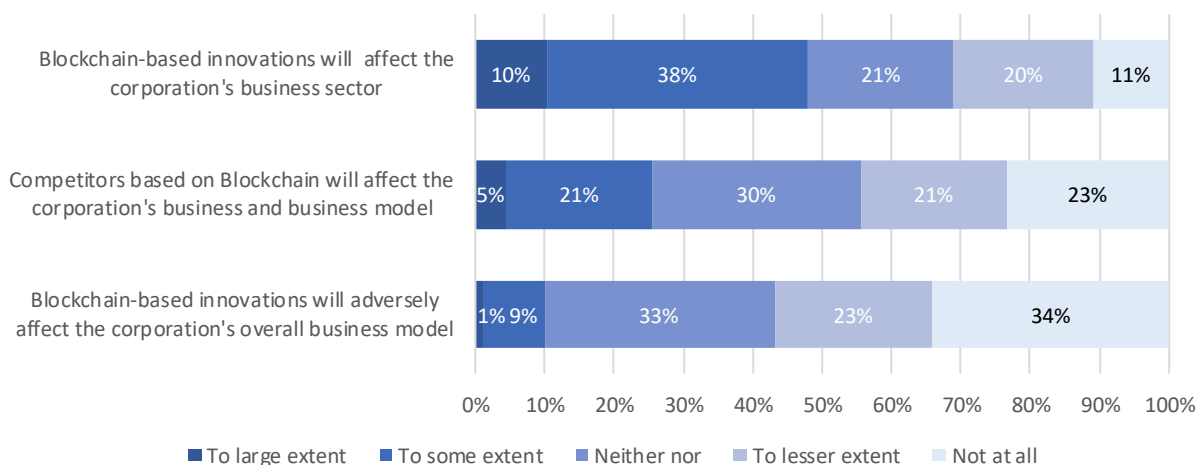


Figure 89: Blockchain as a disruptor of industries (n=365, n=329, n=341)

On the other hand, the share of companies that – at least in their opinion – would have to be afraid of blockchain as it might adversely affect the companies’ business model is with 10 percent (at least to some extent) rather low. This on the first view counterintuitive response is a known phenomenon. On average, respondents overestimate systematically the effect on the environment (their own industry) but underestimate the effect on their own organization (their own business).

However, there is also one third of all companies who answered that their business will not be adversely affected by blockchain at all. For them, blockchain may be an opportunity rather than a threat, which clearly highlights the significance of the technology.

In summary, the adverse effects and effects of competitors are expected to be significantly weaker than the effect of blockchain on the business sector in general. This could be interpreted as the blockchain being seen as a chance for growth more than a risk through competitors and other adverse effects.

Between companies of different sizes there is no significant difference regarding the expected influence of blockchain on their business sector. Larger companies tend to see a bit of a larger influence (Figure 90).

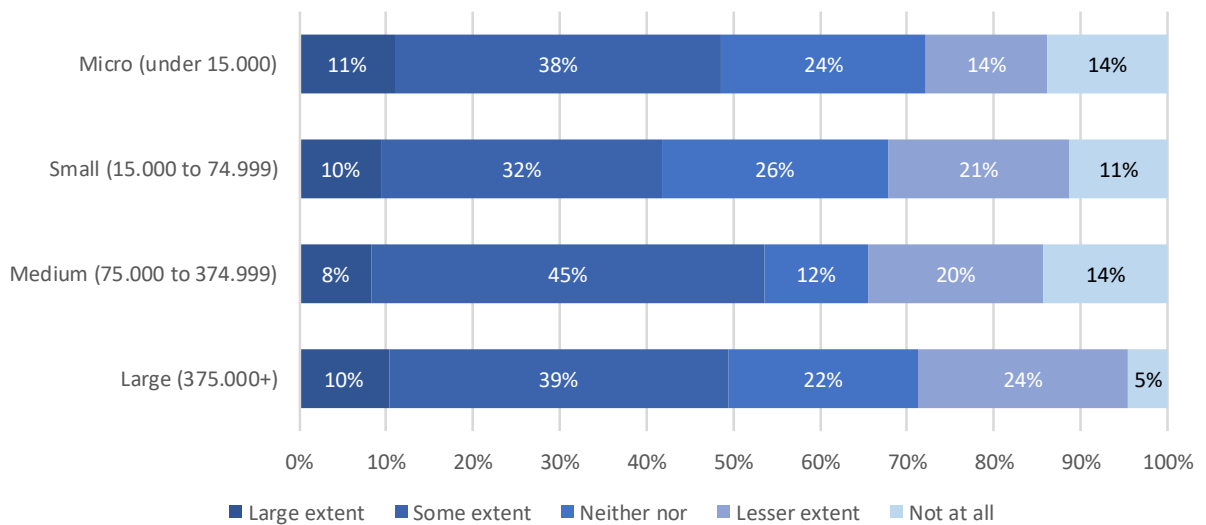


Figure 90: To which extent will blockchain-based innovations affect the corporation's business sector? (by company size in 1,000.- DKK revenue) (n=358)

Regarding the different sectors (Figure 48), the financial and insurance industry sees the largest potential influence with 22 percent expecting an influence to a large extent and in total almost 60 percent at least to some extent.

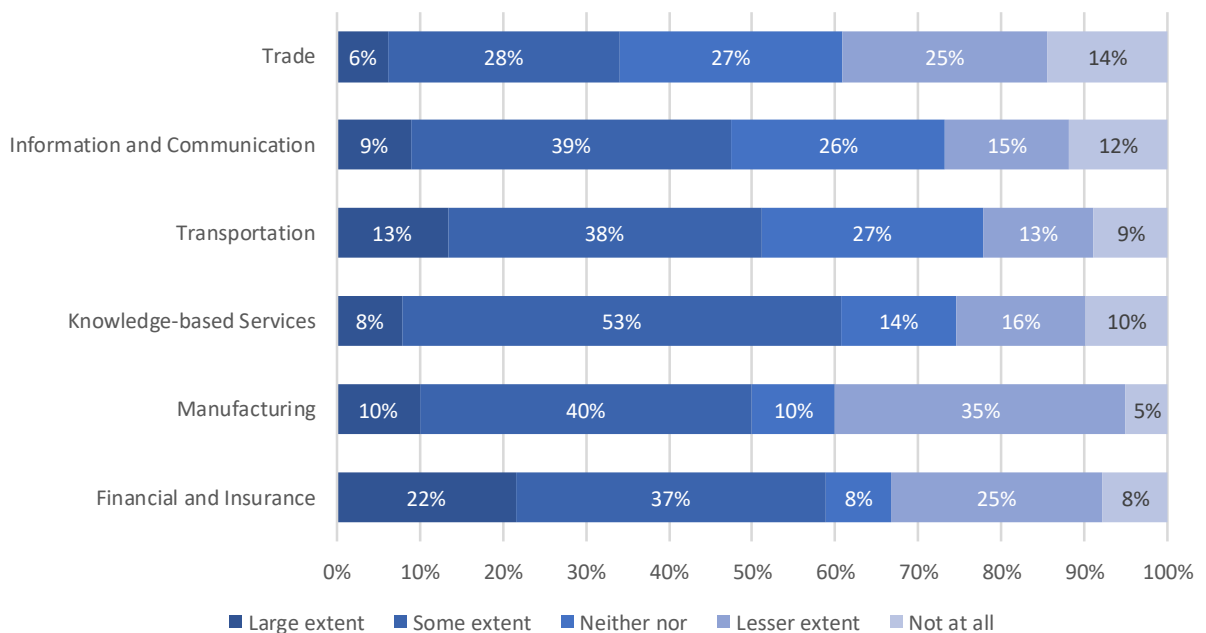


Figure 91: To which extent will blockchain-based innovations affect the corporation's business sector? (by industry sector) (n=365)

In the Knowledge-based services over 60 percent expect at least to some extent a blockchain influence. Finally, even in manufacturing, that is in general quite hesitant towards the technology, only 5 percent of the companies expect no influence at all.

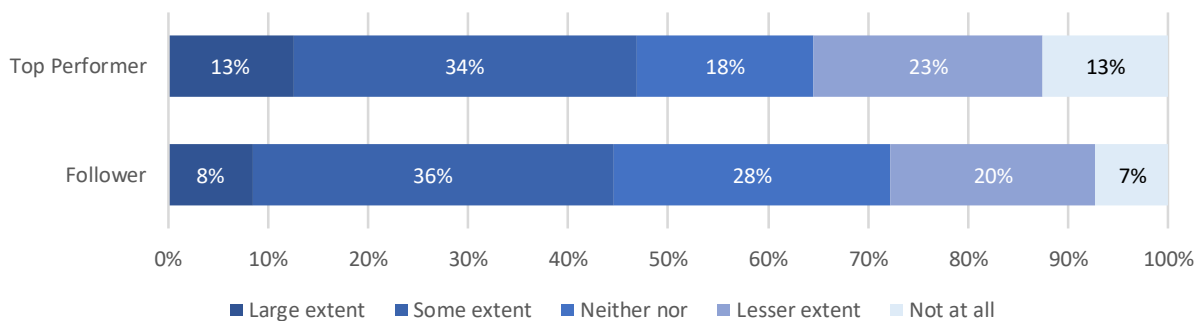


Figure 92: To which extent will blockchain-based innovations affect the corporation's business sector? (by blockchain knowledge) (n=365)

Companies that have a higher knowledge of blockchain expect a higher influence of the technology on their business sector as well, as can be seen in Figure 92. While this may seem self-evident, as if one thinks that this technology will be of great influence it is advisable to also investigate it. However, one could also read this result as that there must be more than just a hype behind blockchain if companies that are highly knowledgeable about the technology still think that it will largely influence their business.

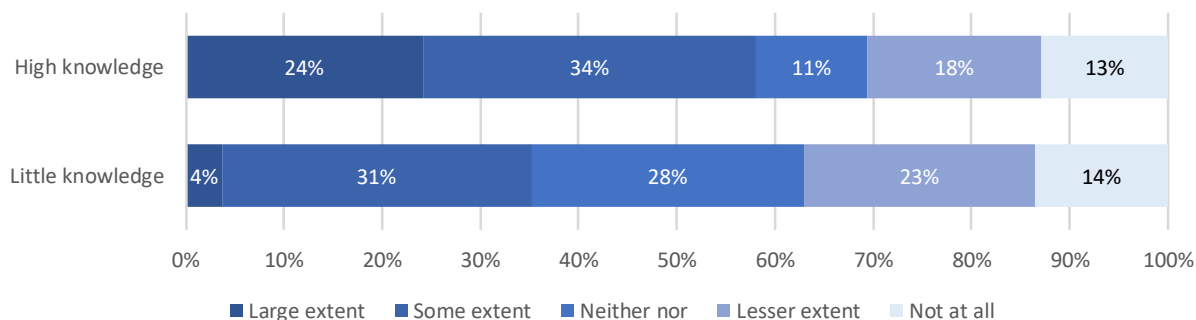


Figure 93: To which extent will blockchain-based innovations affect the corporation's business sector? (by company performance) (n=179)

Economic top performers are relatively divided about the influence of blockchain on their sector (Figure 93), the delta to the followers is not too big.

Strong innovators (Figure 94) and digital leaders (Figure 95) are expecting a significantly higher influence of blockchain on their sectors as their respecting follower groups. This goes in-line with what one expect from both groups – to be open towards new digital innovations and embracing them as a chance for growth.

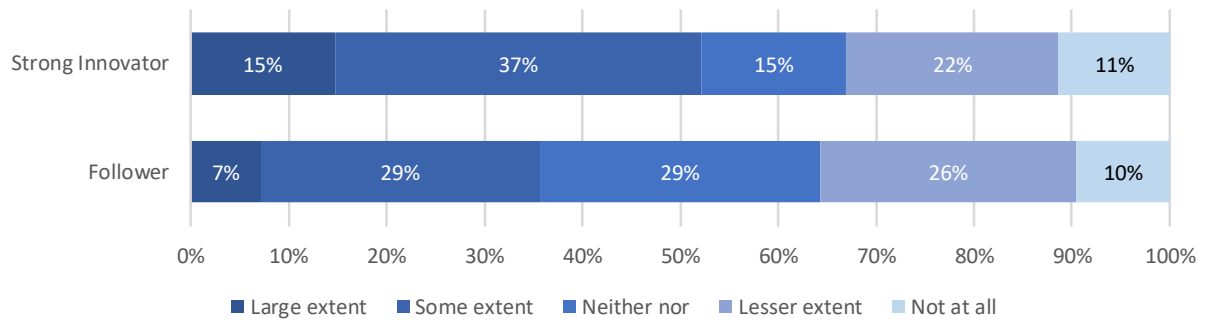


Figure 94: To which extent will blockchain-based innovations affect the corporation's business sector? (strong innovators vs. followers) (n=157)

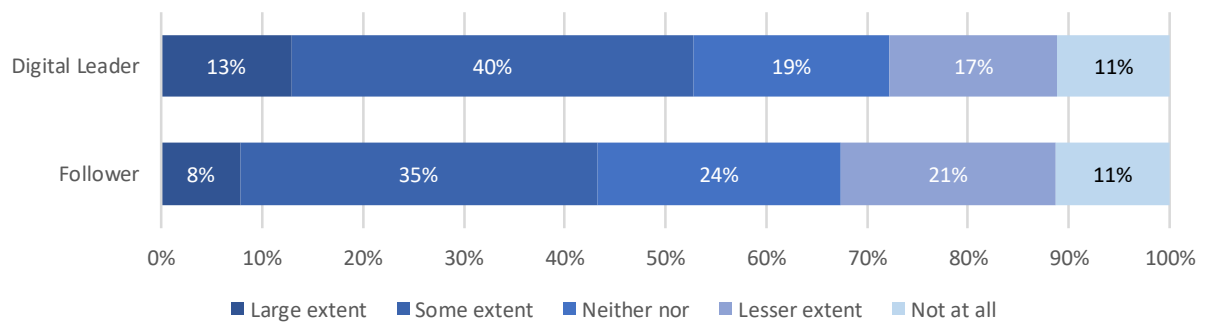


Figure 95: To which extent will blockchain-based innovations affect the corporation's business sector? (digital leaders vs. followers) (n=249)

When focusing on the potential threat through competitors using blockchain solution and the resulting effect on their own companies' business and business model, one can see that on the one hand a larger fraction of smaller companies sees this as a larger issue compared to bigger companies. At the same the share of smaller companies that regards this is as no issue at all is also larger compared with bigger companies (Figure 96).

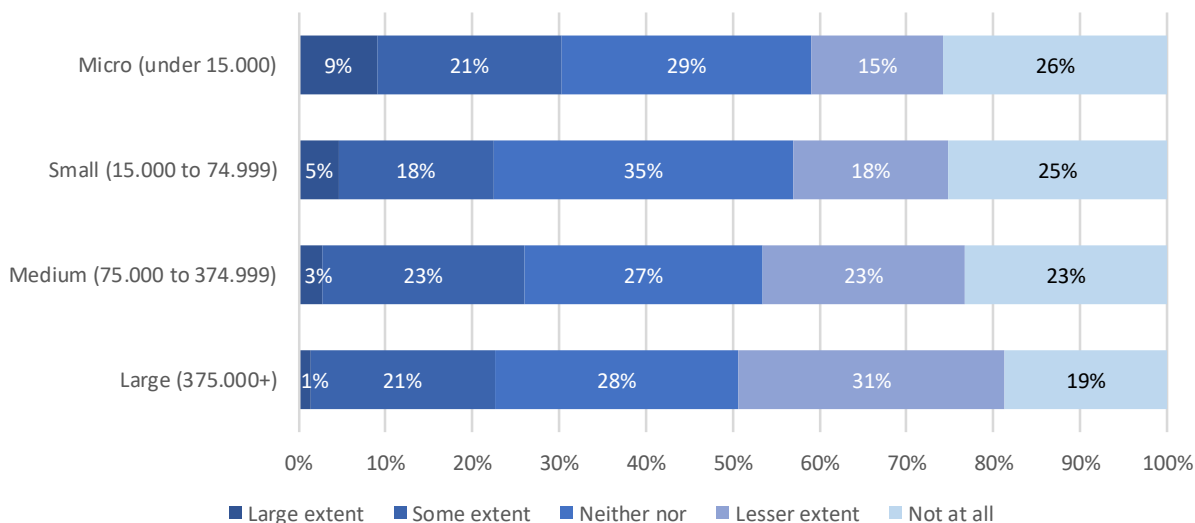


Figure 96: To which extent will competitors based on blockchain affect the corporation's business and business model? (by company size in 1,000.- DKK revenue) (n=321)

The picture is similar to the general influence on the sector (Figure 48) when comparing different industry sectors (Figure 97). The finance and insurance industry as well as knowledge-intensive services industry expect the biggest influence.

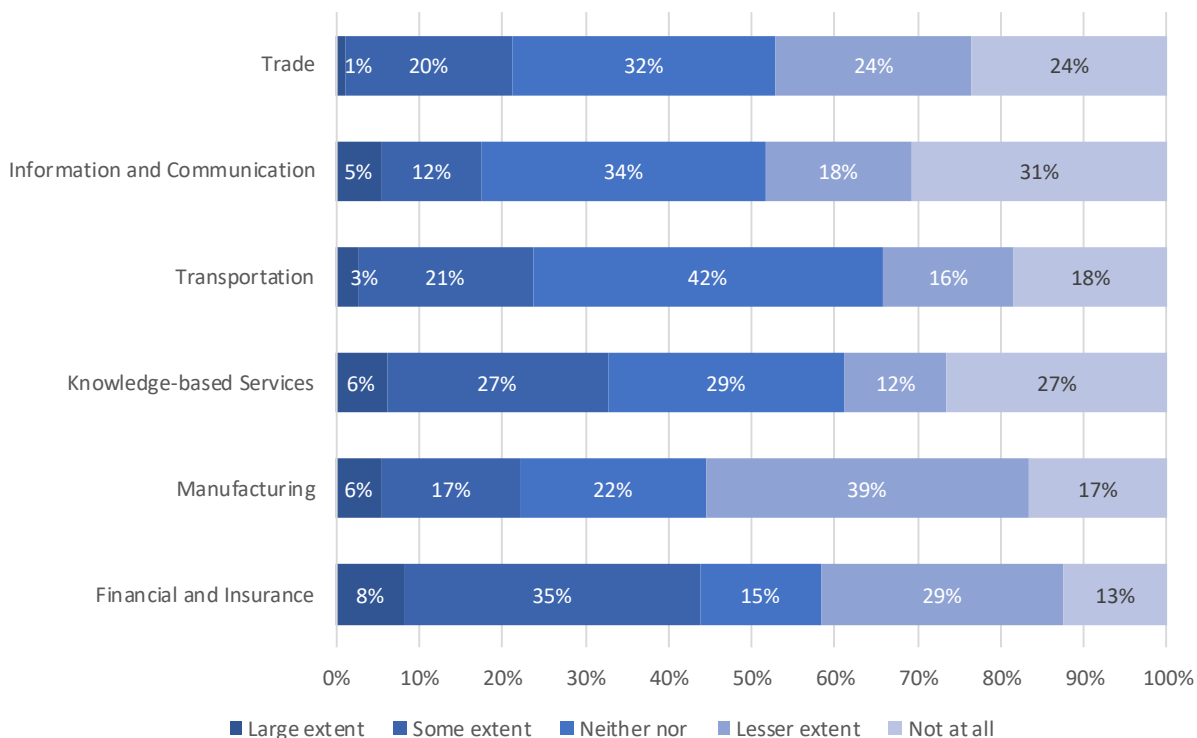


Figure 97: To which extent will competitors based on blockchain affect the corporation's business and business model? (by industry sector) (n=329)

Companies with little knowledge also seem the least concerned about the potential influence of blockchain-based competitors (Figure 98). However, also a quarter of the companies with high knowledge do not expect any influence of competitors on their business at all.

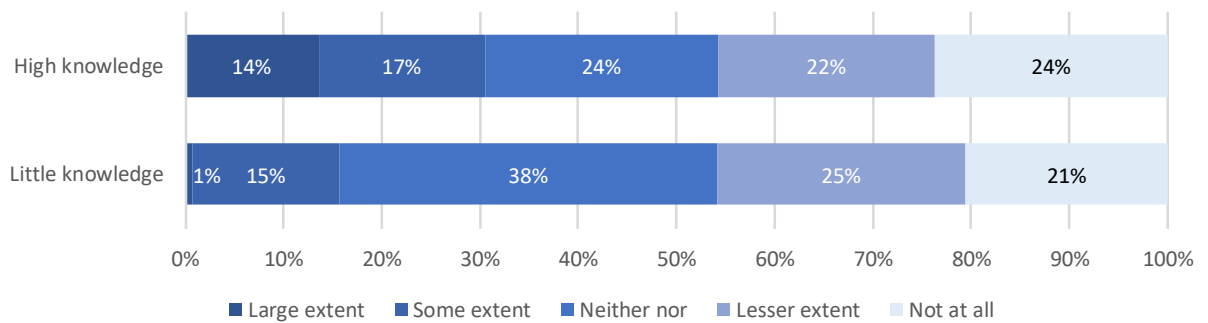


Figure 98: To which extent will competitors based on blockchain affect the corporation's business and business model? (by self-reported blockchain knowledge) (n=329)

Comparing economic top performers and followers shows on the one hand that the top performers seem to feel quite safe in their market position, as 30 percent expect no influence of blockchain-based competitors at all (Figure 99). At the same time, with about one quarter, the share of companies that expect at least to some extent an influence is also higher among the top performers.

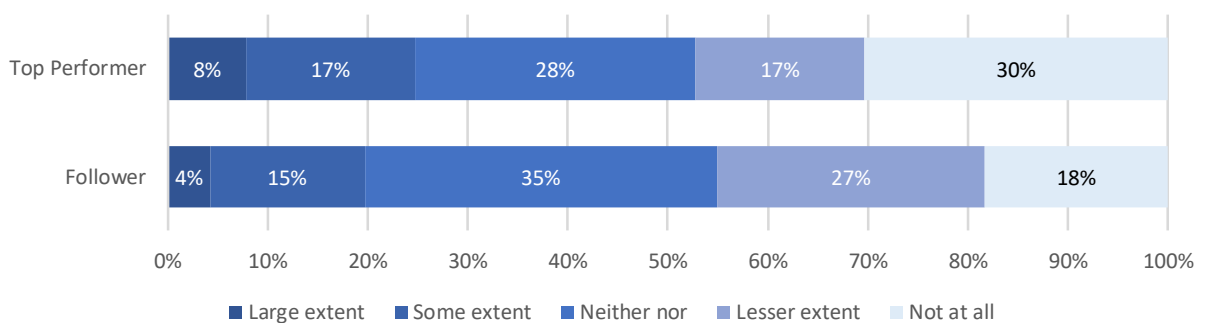


Figure 99: To which extent will competitors based on blockchain affect the corporation's business and business model? (by company performance) (n=160)

A larger percentage of companies is more cautious towards the influence of blockchain-based competitors among strong innovators, while at the same time more than a quarter do not expect any influence at all (Figure 100). None of the followers in this group expect a large influence of competitors which might reflect that these companies are not as open towards innovation as the strong innovators. The results for digital leaders and digital followers are quite similar (Figure 101).

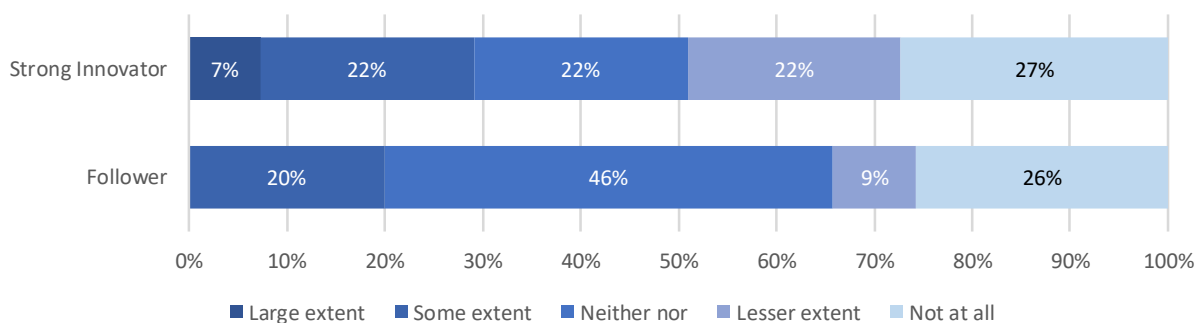


Figure 100: To which extent will competitors based on blockchain affect the corporation's business and business model? (strong innovators vs. followers) (n=145)

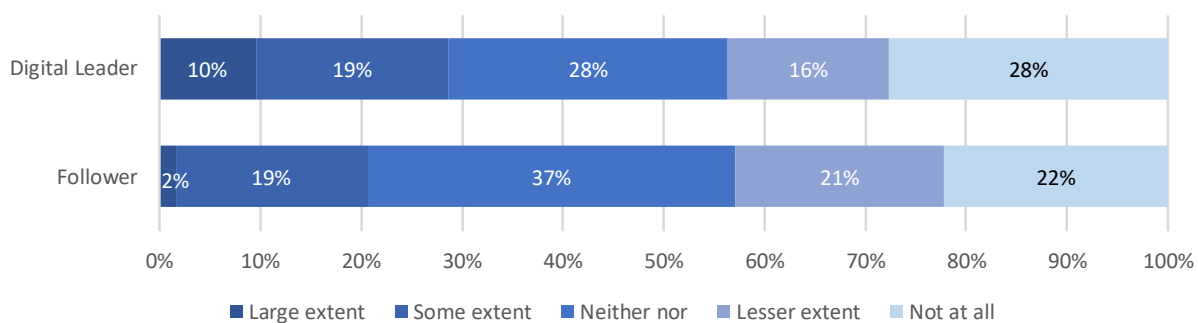


Figure 101: To which extent will competitors based on blockchain affect the corporation's business and business model? (digital leaders vs. followers) (n=220)

The percentage of companies that see blockchain-based innovations as potentially adversely affecting their business model is the smallest among micro companies, but in general the variance is not too large (Figure 102).

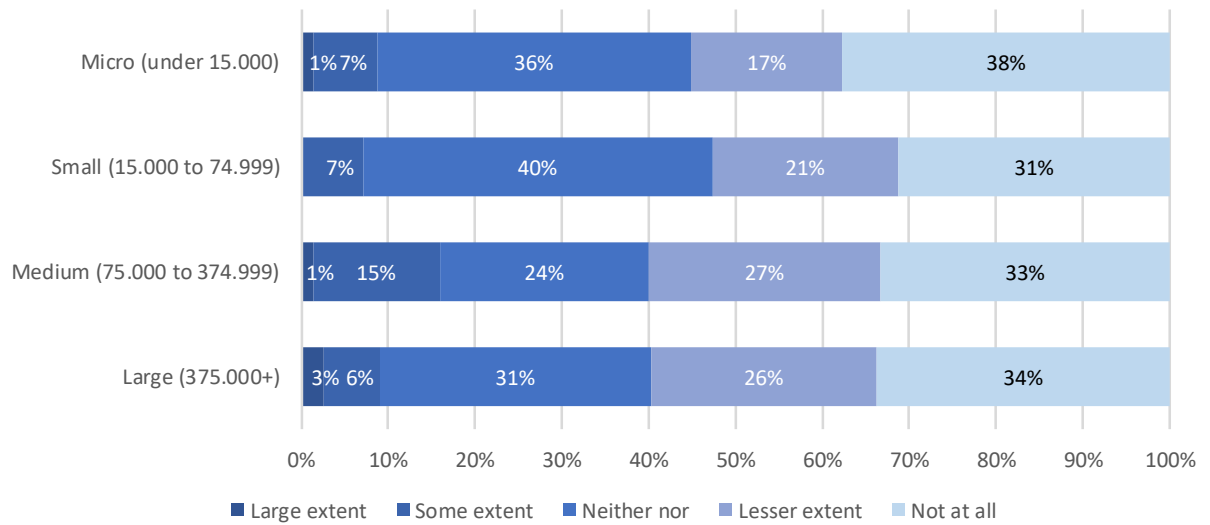


Figure 102: To which extent will blockchain-based innovations adversely affect the corporation's overall business model? (by company size in 1,000.- DKK revenue) (n=333)

It is interesting that while one expect that the financial services and insurance industry might be very cautious and conservative, none of the companies in our sample expects an adverse effect to a large extent (Figure 103). However, together with the transportation industry, it is the industry with the largest percentage of companies expecting at least an effect “to a lesser extent”.

Another surprise might be that the manufacturing industry has the largest number of companies that strongly see a potential adverse effect, while judging from the other questions, many companies of this industry do not seem to take blockchain too seriously at this point.

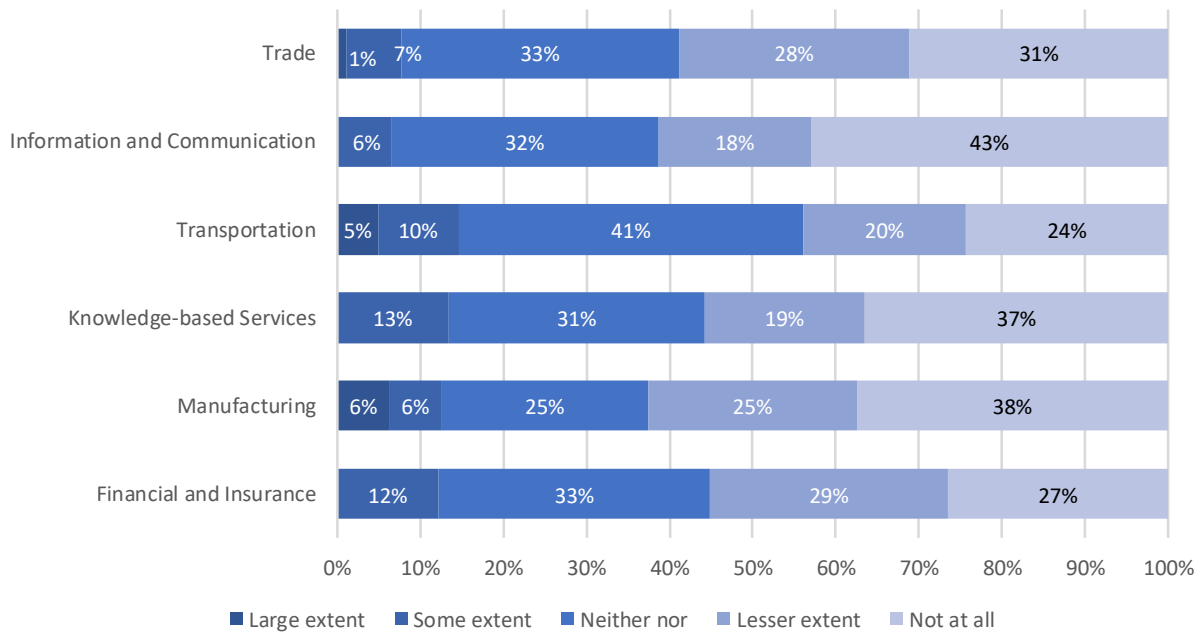


Figure 103: To which extent will blockchain-based innovations adversely affect the corporation's overall business model? (by industry sector) (n=341)

The situation illustrated in Figure 104 is very similar to the one in Figure 98, where more companies with high knowledge about blockchain expect more potential negative effects than companies with little knowledge, while at the same time the percentage of companies that see no adverse effect at all is also higher among companies with high knowledge.

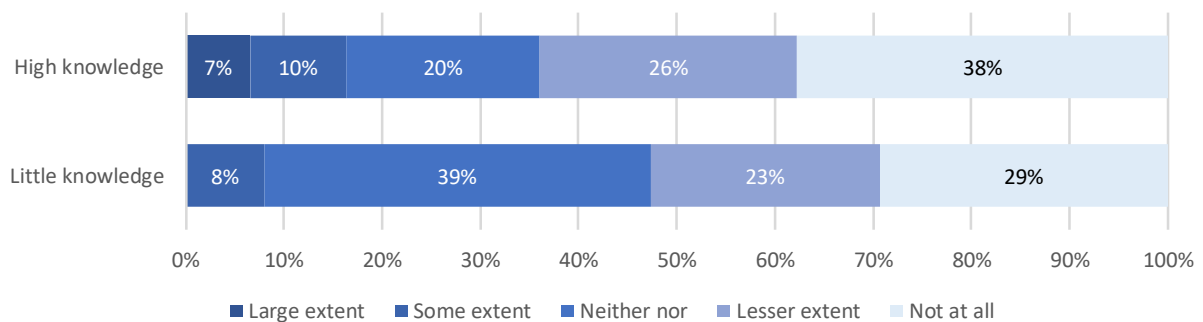


Figure 104: To which extent will blockchain-based innovations adversely affect the corporation's overall business model? (by self-reported blockchain knowledge) (n=341)

Economic top performers again seem to feel safer in their position regarding blockchain-related adverse effects on their business model (Figure 105), but here as well, the fraction of top performers that see a potential strong negative impact is higher than among the followers – where no company expect such a strong effect.

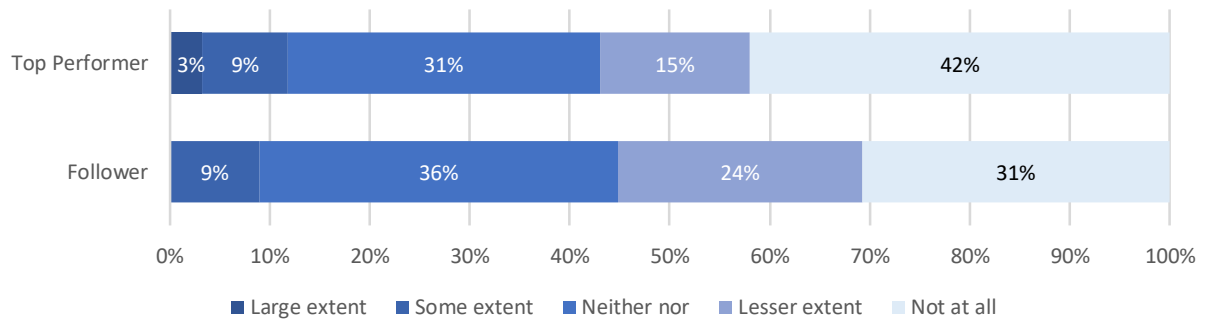


Figure 105: To which extent will blockchain-based innovations adversely affect the corporation's overall business model? (by company performance) (n=171)

Just like with the previous question (Figure 100 and Figure 101) we see that strong innovators (Figure 106) and digital leaders (Figure 107) regard innovative technologies as chances rather than threats as one could derive from the high percentage of companies that do not see any adverse effects of blockchain on their business model at all.

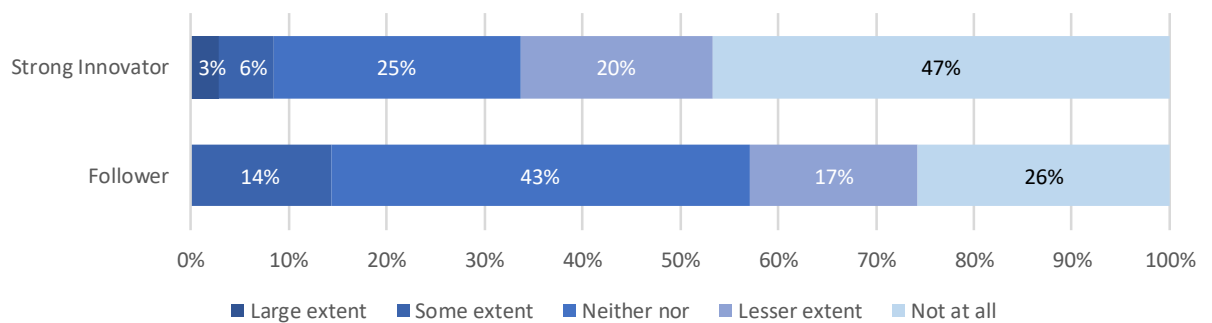


Figure 106: To which extent will blockchain-based innovations adversely affect the corporation's overall business model? (strong innovators vs. followers) (n=142)

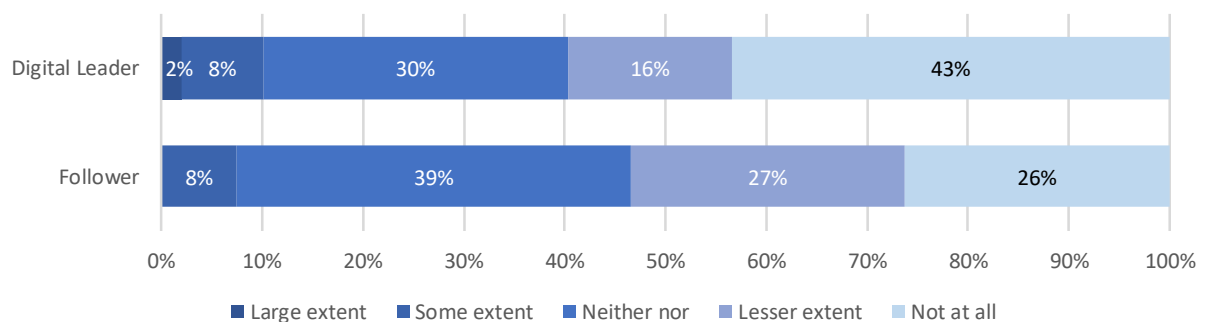


Figure 107: To which extent will blockchain-based innovations adversely affect the corporation's overall business model? (digital leaders vs. followers) (n=232)

After analyzing the expectations of companies towards blockchain as a potentially negative disruptor, we are now turning to the potential effects of blockchain as an accelerator for companies' businesses. Therefore, four main questions were asked to corporations. They considered whether or not corporations thought that new business models based on blockchain could help improve the corporations' new revenue sources and improve competitiveness; whether they envisioned that blockchain-based systems would be a part of the corporations business in the next two years, and whether blockchain-based innovation would create jobs.

In order to grasp a perspective of how influential blockchain might be on a company's business will be, a question comparing the impact of blockchain in regards to the impact of the Internet on the company has been asked.

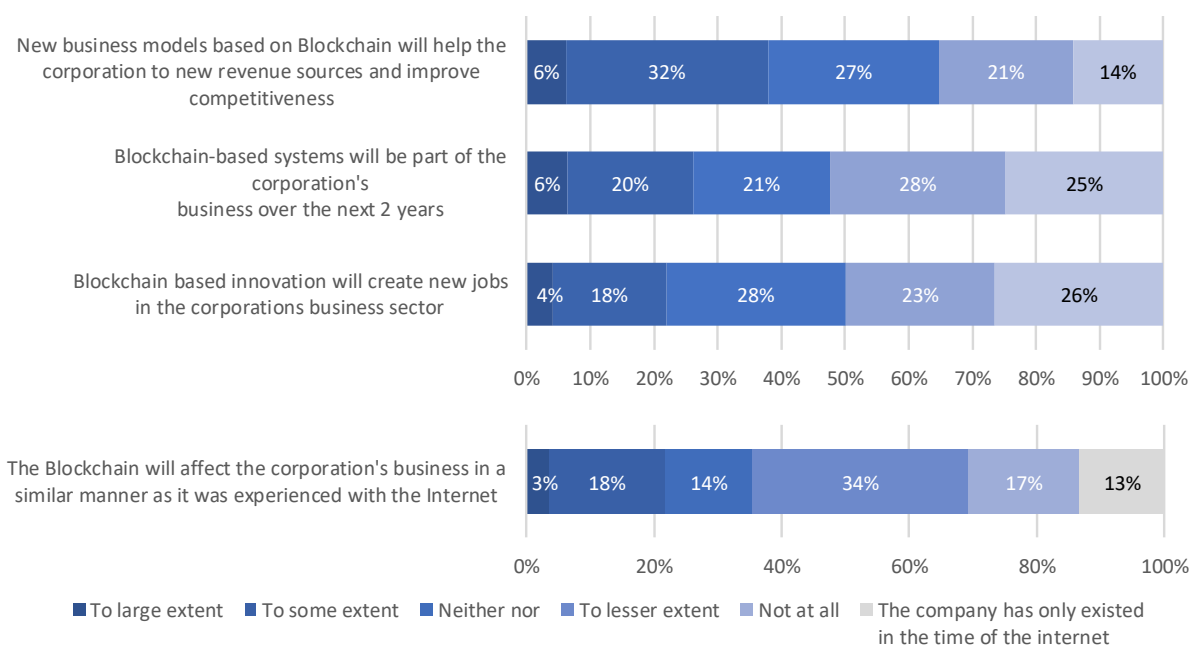


Figure 108: Blockchain as an accelerator of competitive advantage (n=324, n=340, n=337, n=373)

More than one third of all corporations say that at least to some extent business models based on blockchain would help the corporations to get new sources of revenue and improve on competitiveness.

However, Figure 108 also shows that blockchain is still a new technology, as a quarter of all companies do not expect it to be part of their business in the next two years and another 28 percent only to a lesser extent – which of course means that at the same time 26 percent of the companies at least to some extent see it as being a part. With that, 49 percent say that they do not believe that blockchain-based innovations will create new jobs in their industry.

The results were very heterogeneous with regards to the impact comparison between blockchain and the Internet on companies. This could be seen as a reflection of many

different aspects, such as, how young the technology is, where it is on the hype cycle, or the uncertainties about the potentials of the new technology.

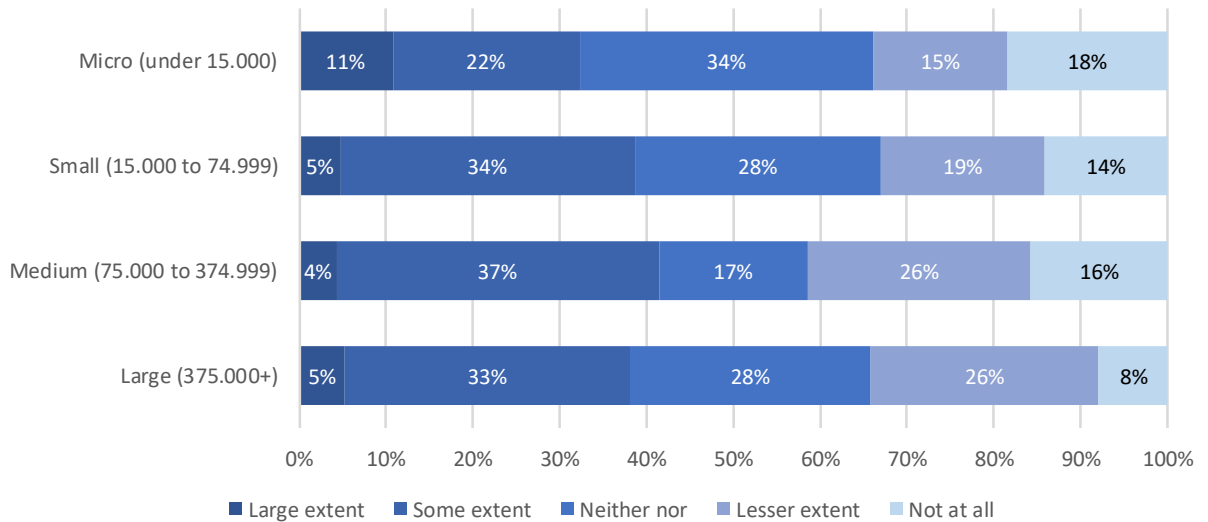


Figure 109: To which extent will new business models based on blockchain help the corporation to develop new revenue sources and improve competitiveness? (by company size in 1,000.- DKK revenue) (n=317)

The variance between companies of different size regarding their expectation towards blockchain as a chance to create new revenue sources and to improve competitiveness is not very strong (Figure 109). Among micro companies, both the percentage of respondents that agree to a large extent as well as those that do not agree at all is the highest.

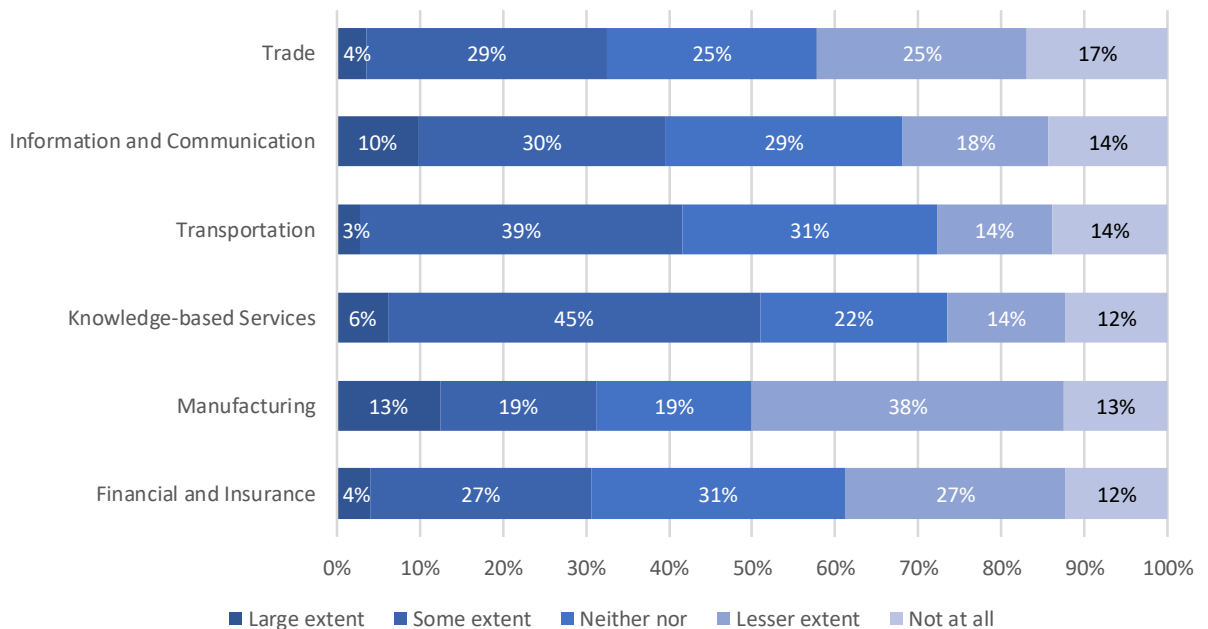


Figure 110: To which extent will new business models based on blockchain help the corporation to develop new revenue sources and improve competitiveness? (by industry sector) (n=324)

More than half of the companies in the knowledge-based services industry, and around 40 percent of those in the information technology and communication industry, as well as transportation industry expect at least to some extent new revenue sources and improved competitiveness (Figure 110). This is a strong statement.

The percentage of those that do not expect any influence at all is in contrast quite low, ranging between 12 and 17 percent. This all highlights that across industries, blockchain is seen as a potential accelerator.

Moreover, despite the hype around cryptocurrencies, the financial services and insurance industry does not expect the largest influence of blockchain, but other industries do.

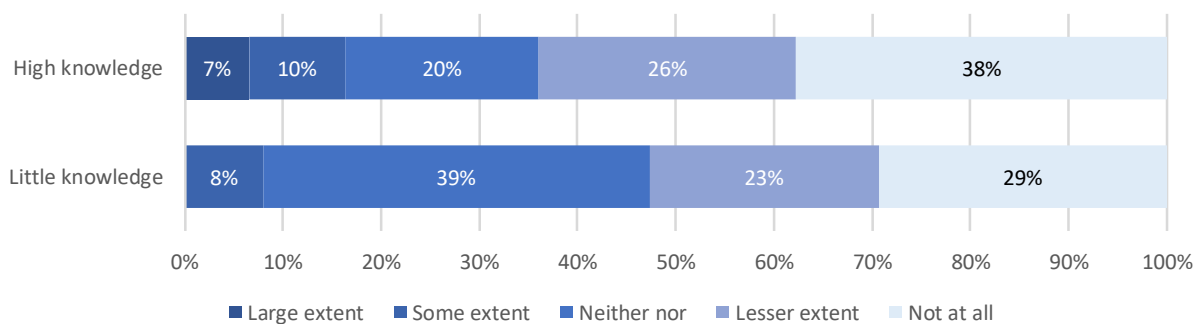


Figure 111: To which extent will new business models based on blockchain help the corporation to develop new revenue sources and improve competitiveness? (by self-reported blockchain knowledge) (n=324)

Unsurprisingly, Figure 111 shows that companies with high blockchain knowledge expect a greater positive influence of the technology on their business. Working with blockchain already or investigating the technology further seem to have not let to discouragement or disillusion about its potential.

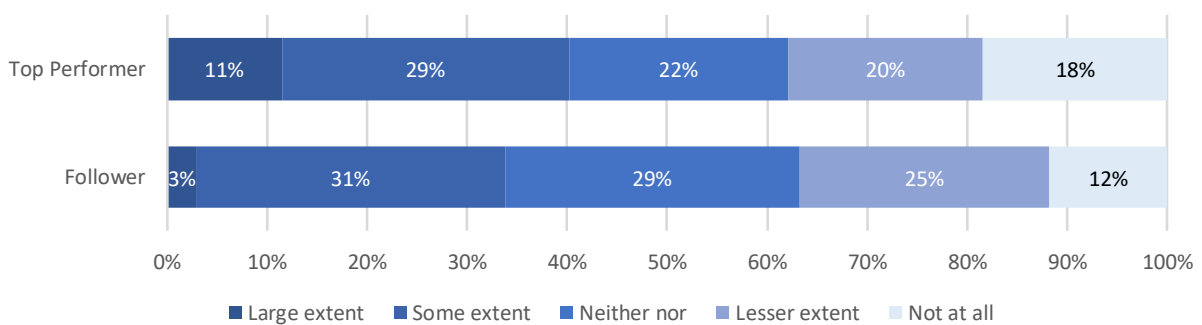


Figure 112: To which extent will new business models based on blockchain help the corporation to develop new revenue sources and improve competitiveness? (by company performance) (n=155)

The share of companies that expect a positive influence of the technology on their business is significantly higher among economic top performers than among the followers (Figure 112). Also, 18 percent – more than among the followers – do not expect any positive

influence at all which cannot result from a general tendency of these companies to answer in a more positive way.

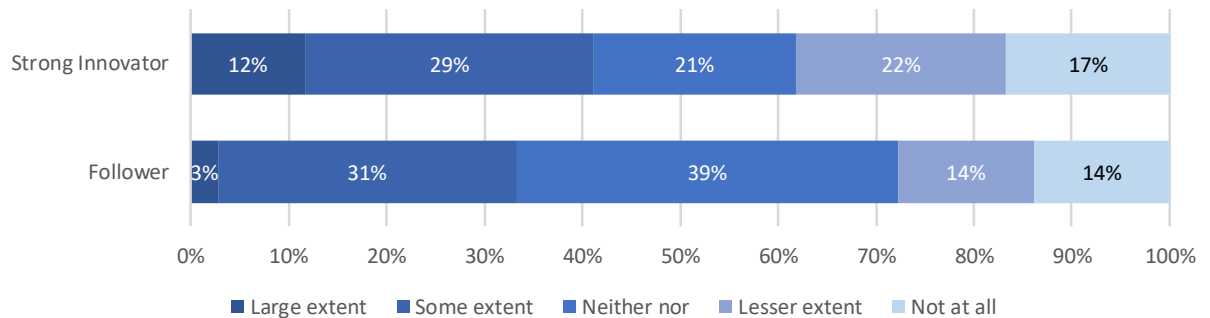


Figure 113: To which extent will new business models based on blockchain help the corporation to develop new revenue sources and improve competitiveness? (strong innovators vs. followers) (n=138)

Strong innovators (Figure 113) as well as digital leaders (Figure 114) are again expecting more positive effects of the technology than their respective follower groups.

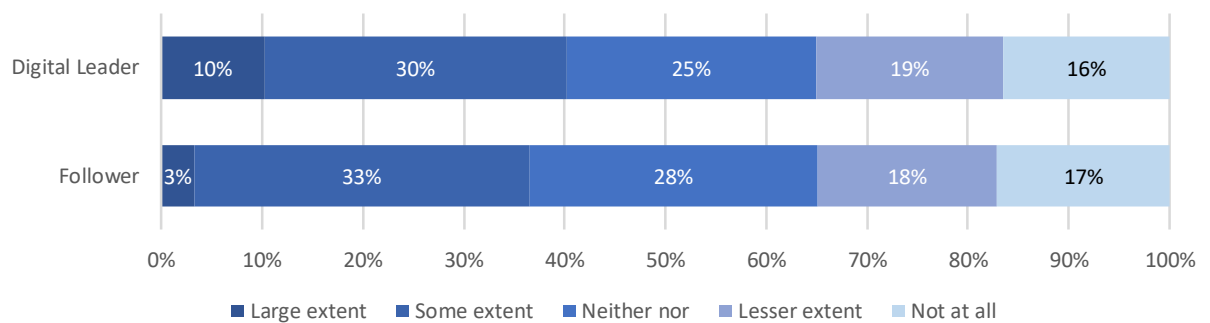


Figure 114: To which extent will new business models based on blockchain help the corporation to develop new revenue sources and improve competitiveness? (digital leaders vs. followers) (n=220)

That blockchain will create new jobs is expected strongest among micro companies or startups. As companies get larger, this expectation gradually decreases (Figure 115). In this case we can potentially observe that digitally born micro companies in general expect to grow and create new jobs and that in this case they connect this expectation with the blockchain technology.

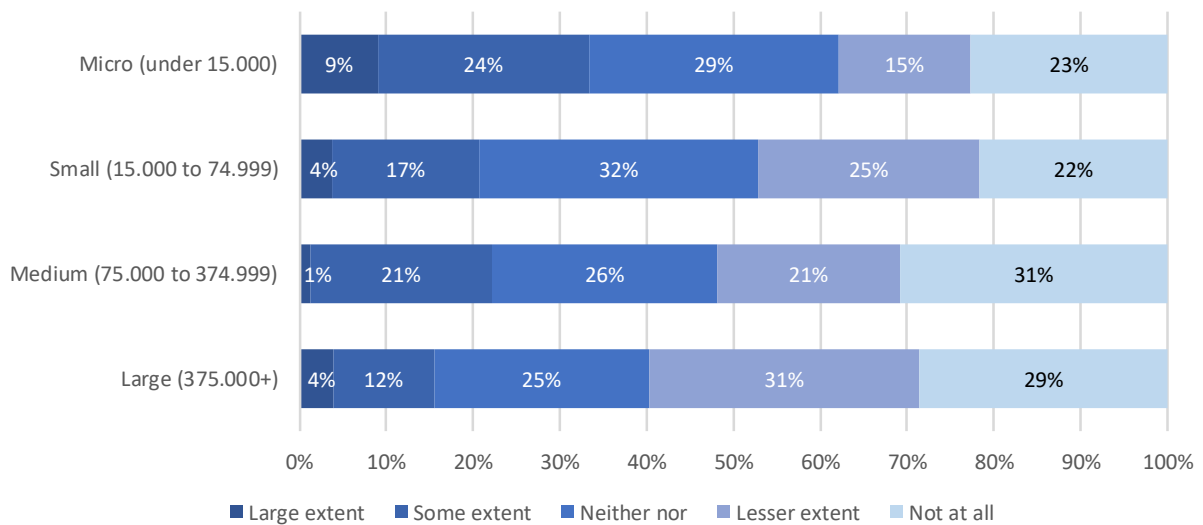


Figure 115: To which extent will blockchain-based innovation create new jobs in the corporation's industry sector? (by company size in 1,000.- DKK revenue) (n=330)

The information technology and communication industry as well as the knowledge-based services industry are those where the largest percentage of companies expect the creation of new jobs through blockchain-based innovation (Figure 116). The manufacturing industry, on the other hand, is more skeptical. This is a bit of a surprise, as the Internet of Things and the Industry 4.0 will most likely operate on a blockchain system.

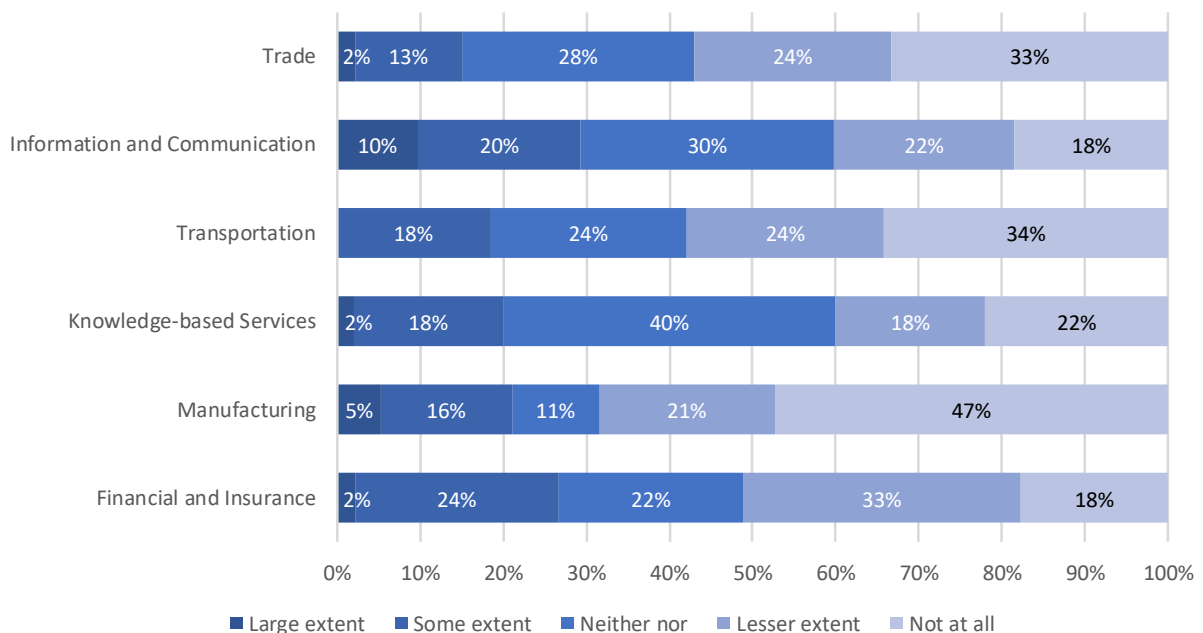


Figure 116: To which extent will blockchain-based innovation create new jobs in the corporation's industry sector? (by industry sector) (n=337)

Companies with high knowledge in blockchain (Figure 117), as well as strong innovators (Figure 118), and digital leaders (Figure 119) have more positive expectations regarding the creation of new jobs through blockchain technology, compared to the companies in their respective counter groups.

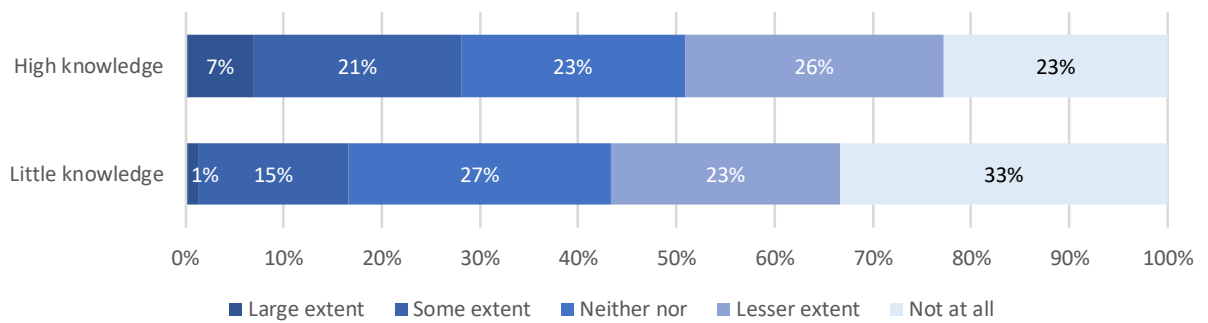


Figure 117: To which extent will blockchain-based innovation create new jobs in the corporation's industry sector? (by self-reported blockchain knowledge) (n=337)

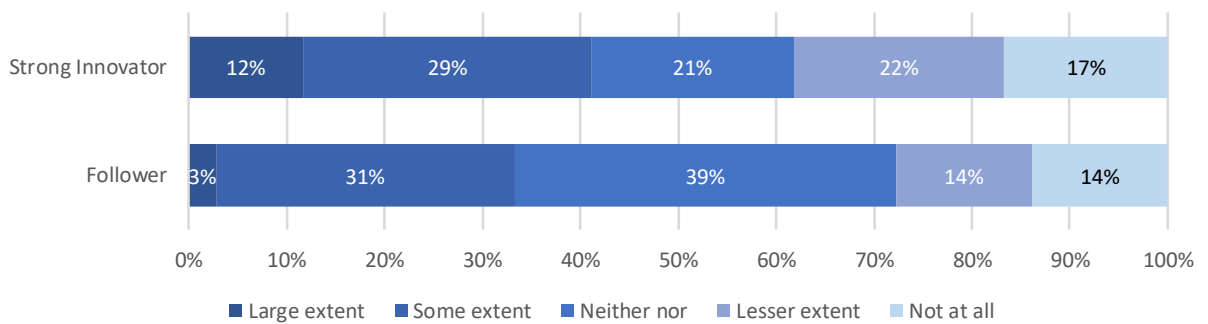


Figure 118: To which extent will blockchain-based innovation create new jobs in the corporation's industry sector? (strong innovators vs. followers) (n=145)

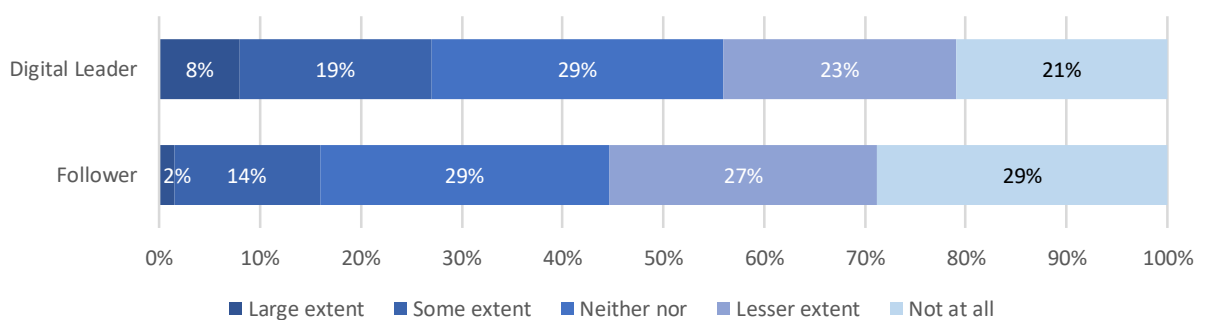


Figure 119: To which extent will blockchain-based innovation create new jobs in the corporation's industry sector? (digital leaders vs. followers) (n=232)

Economically top performers are divided (Figure 120), as a larger percentage than among followers expect job growth, while at the same time a larger percentage expects no job growth at all.

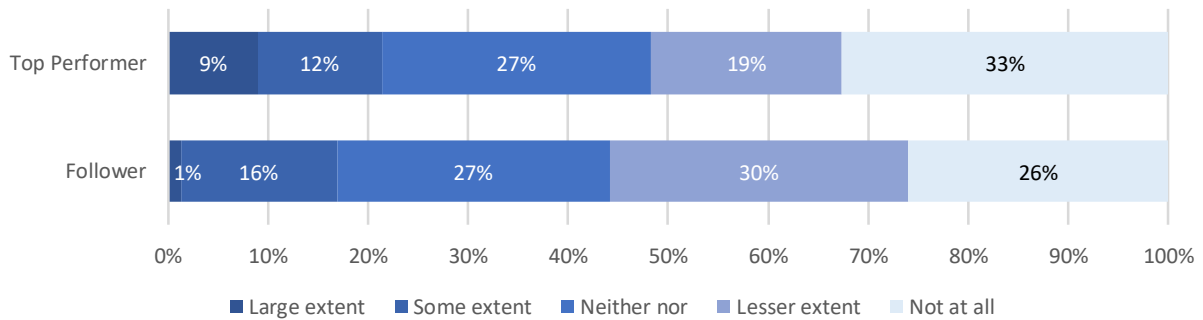


Figure 120: To which extent will blockchain-based innovation create new jobs in the corporation's industry sector? (by company performance) (n=166)

Looking into the future, companies of different sizes mainly differ regarding their expectation whether blockchain will not at all be a part of their business over the next 2 years (Figure 121). Larger percentages of smaller companies are more certain that blockchain will not become part of their business in the next two years than bigger companies.

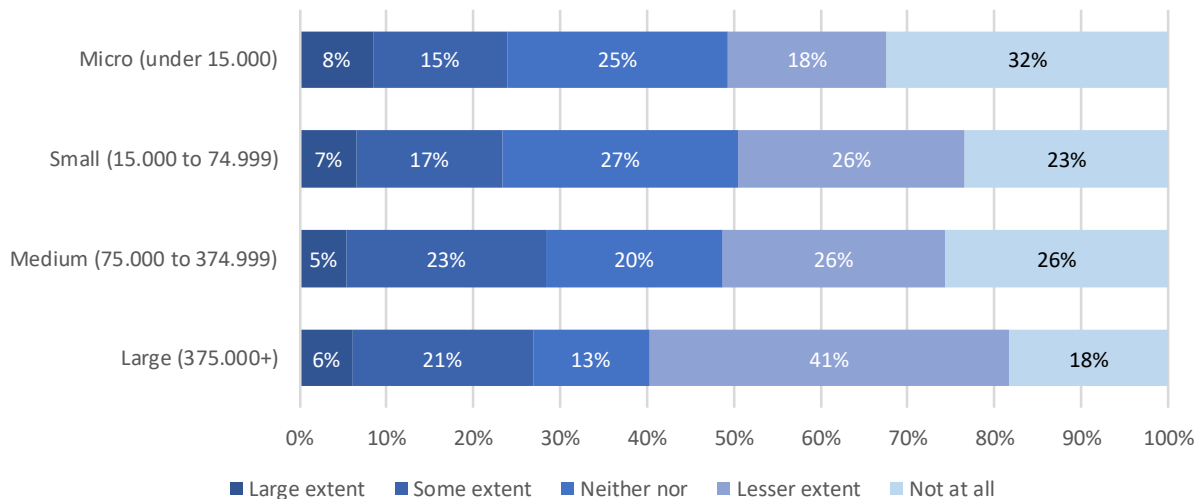


Figure 121: To which extent will blockchain-based systems become a part of the corporation's business over the next 2 years? (by company size in 1,000.- DKK revenue) (n=334)

The information technology and communication industry, as well as the knowledge-based services industry and the financial services and insurance industry seem to be the ones where blockchain-based systems will first become a part of the business IT infrastructure (Figure 122). Around one third of the companies in those sectors expect that to be the case within the next two years. In the manufacturing industry as well as in trade, the application

of blockchain solutions seem to be less of importance in the next two years. It is interesting to note that at the same time 35 percent of the companies in the knowledge-based services industry also think that blockchain will not at all become a part of their business within the next two years. Among those companies are consulting and accounting firms.

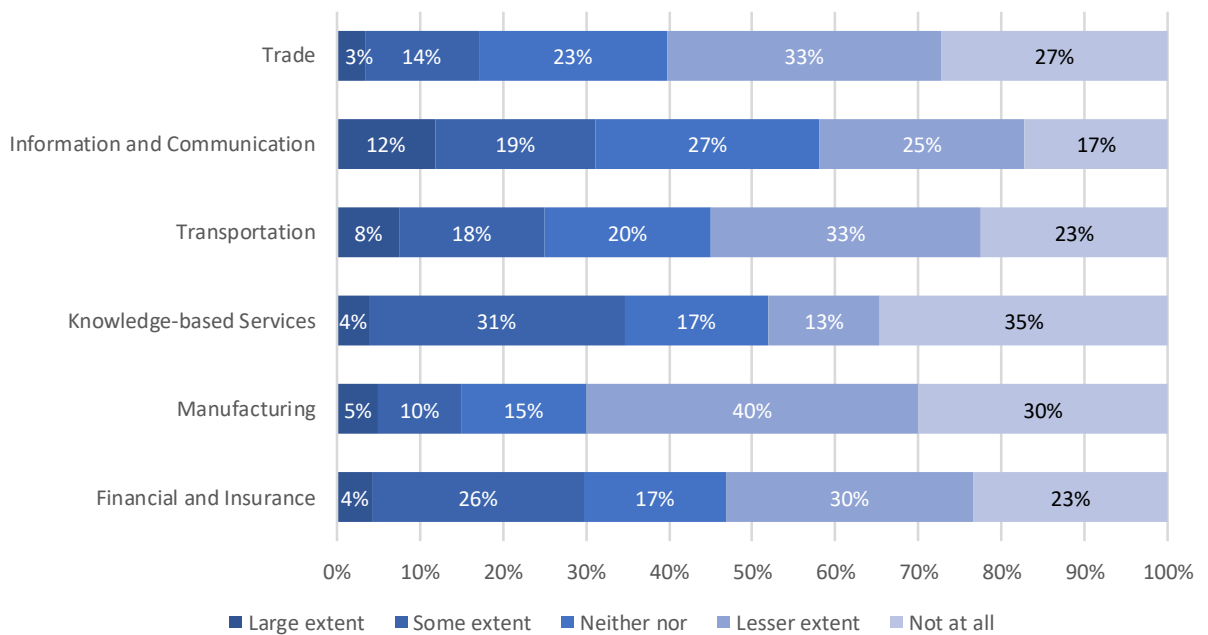


Figure 122: To which extent will blockchain-based systems become a part of the corporation's business over the next 2 years? (by industry sector) (n=340)

The higher the blockchain-knowledge of the companies, the higher the likelihood that they expect that blockchain-based systems will become a part of their business over the next 2 years, as can be seen in Figure 123. Here again, a deeper investigation of current blockchain solutions seemingly has not significantly lowered their expectations.

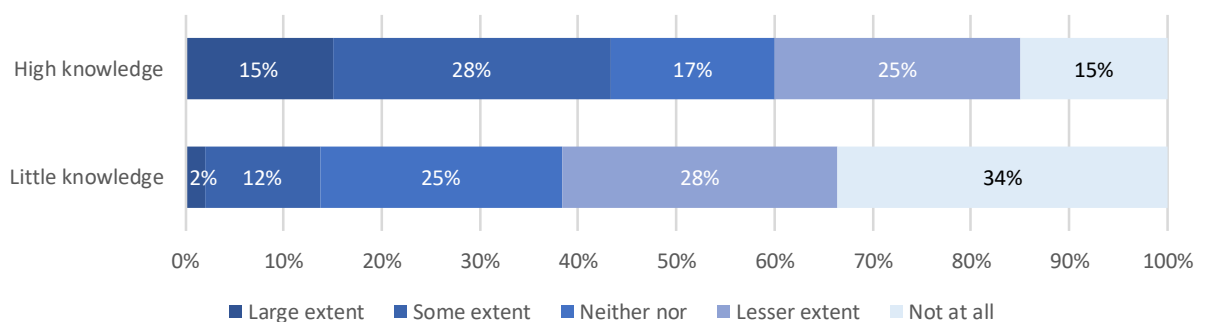


Figure 123: To which extent will blockchain-based systems become a part of the corporation's business over the next 2 years? (by self-reported blockchain knowledge) (n=340)

When comparing economically top performers (Figure 124), strong innovators (Figure 125), and digital leaders (Figure 126) with their respective follower groups, one can observe a tendency towards a larger percentage of companies being more positive towards blockchain being implemented in the near future.

Between approximately one quarter and one third of the companies in the top groups expect at least to some extent the adoption of blockchain over the next two years.

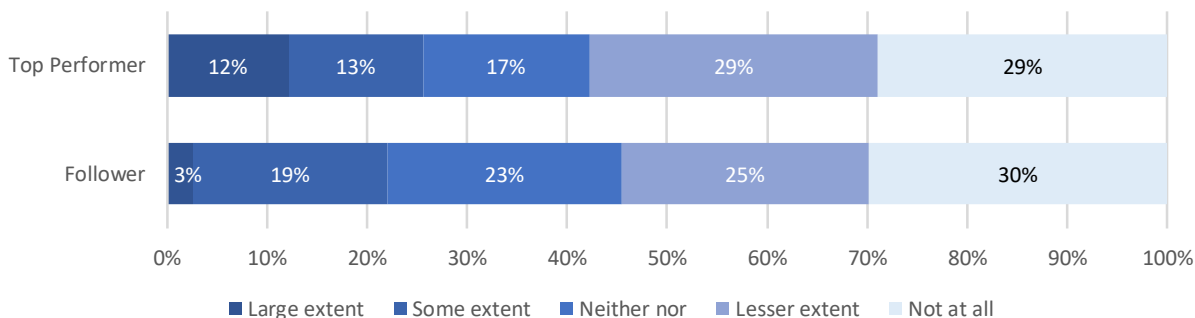


Figure 124: To which extent will blockchain-based systems become a part of the corporation's business over the next 2 years? (by company performance) (n=167)

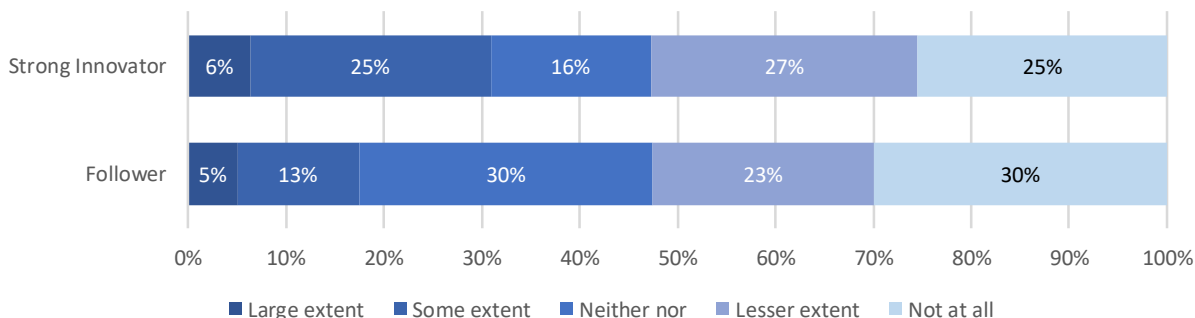


Figure 125: To which extent will blockchain-based systems become a part of the corporation's business over the next 2 years? (strong innovators vs. followers) (n=150)

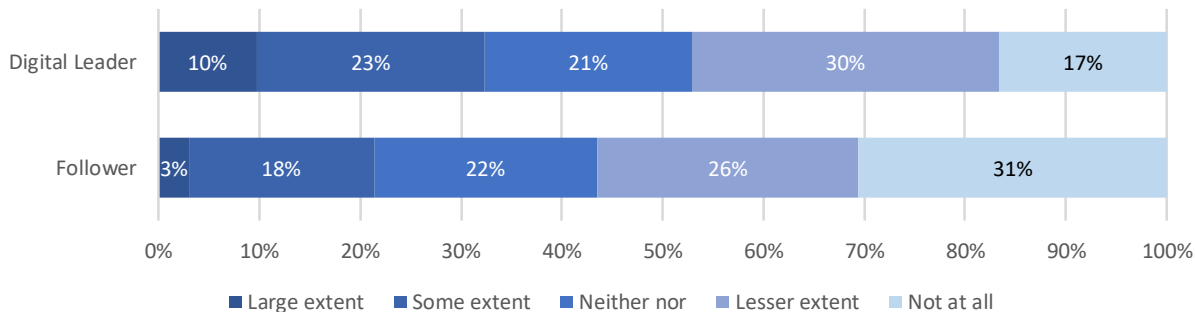


Figure 126: To which extent will blockchain-based systems become a part of the corporation's business over the next 2 years? (digital leaders vs. followers) (n=233)

A more thorough analysis of the perceived impact blockchain may have on businesses is focused on in the following, where companies were asked to assess the impact of blockchain relative to the impact of the Internet (Figure 127). For this analysis, this report looked at various types of attributes and characteristics of companies.

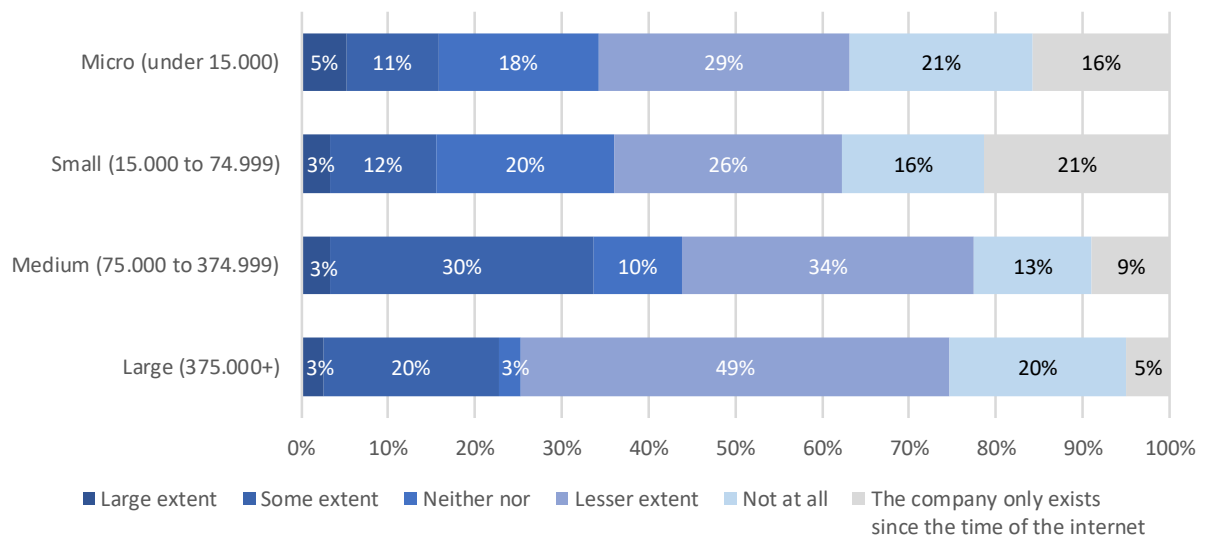


Figure 127: To which extent will blockchain affect the corporation's business in a similar manner as it was experienced with the internet? (by company size in 1,000.- DKK revenue) (n=366)

With regards to size of the company, large and medium sized corporations appeared to see the impact of blockchain as something more similar to the impact of the Internet than the smaller sized companies. This could attribute that larger companies have had more resources to investigate and to try out blockchain projects or activities and therefore are able to see the potential impact it may have on their corporation in comparison to smaller sized companies.

With regard to industry (Figure 128), we see that the top industries that have more than some extent of belief that the impact will be similar are the trade and transportation industry with 27 percent and the information technology and communication industry, as well as the financial services and insurance industry with 20 percent. With that, the majority does not believe that the impact will be as great as the impact of the Internet.

With regards to the financial and insurance industry, it makes sense that they are a part of this given the awareness of Bitcoin and cryptocurrency use cases. Many use cases have been tested and praised in relation to logistics, especially in transportation and shipping, which is particularly important for Denmark, and which is closely related to the trade industry.

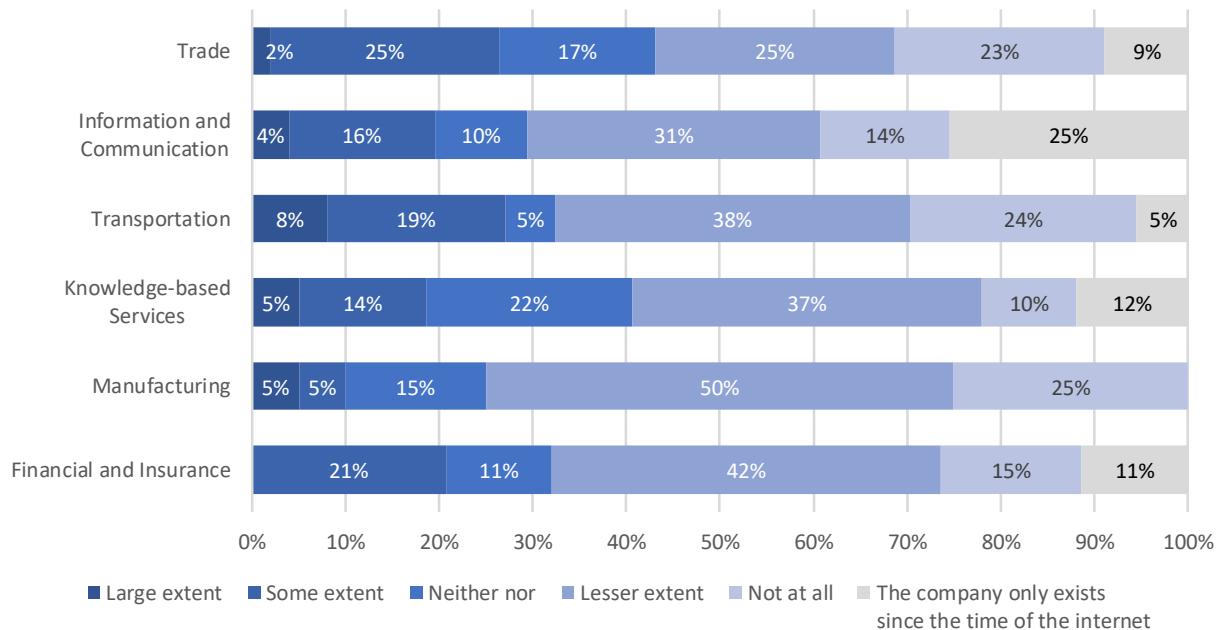


Figure 128: To which extent will blockchain affect the corporation's business in a similar manner as it was experienced with the internet? (by industry sector) (n=373)

In comparison of those who are grouped as with either high blockchain knowledge vs. low blockchain knowledge (Figure 129), the perspective if blockchain will have an as significant impact as the Internet was positive in the sense that those with high knowledge of blockchain saw that its impact to be greater than those with low knowledge of blockchain.

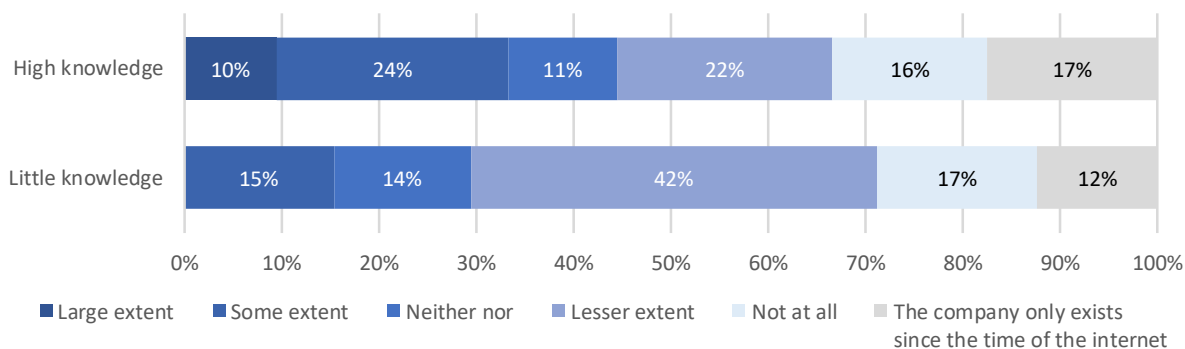


Figure 129: To which extent will blockchain affect the corporation's business in a similar manner as it was experienced with the internet? (by self-reported blockchain knowledge) (n=373)

Looking into the ambitious companies (top performers, digital leaders, and strong innovators), the results of (Figure 130, Figure 131, and Figure 132) were all quite similar and provided no significant difference between them and the group of followers.

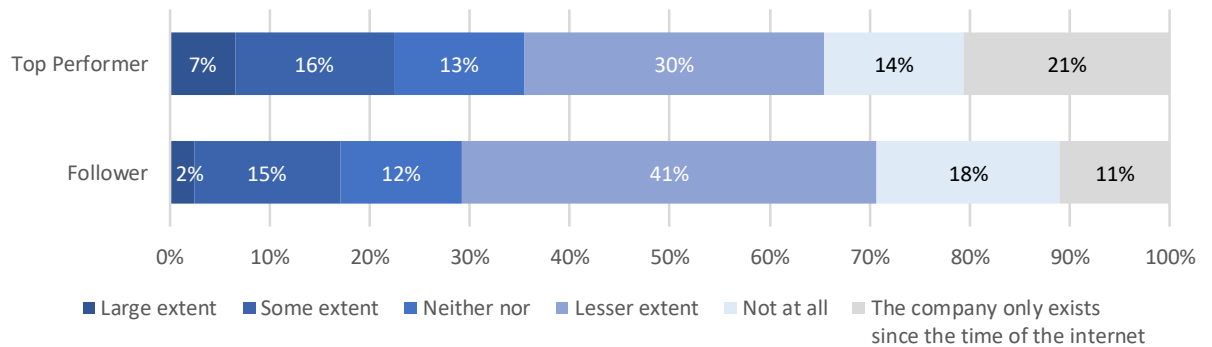


Figure 130: To which extent will blockchain affect the corporation's business in a similar manner as it was experienced with the internet? (by company performance) (n=189)

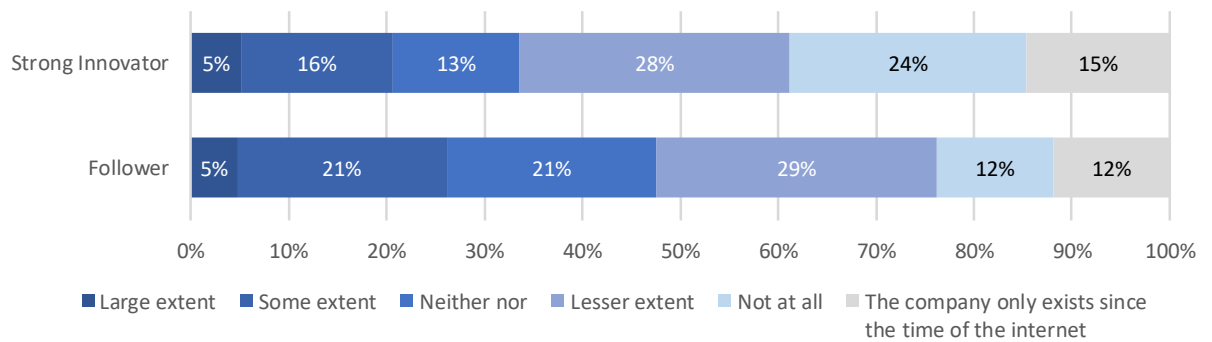


Figure 131: To which extent will blockchain affect the corporation's business in a similar manner as it was experienced with the internet? (strong innovators vs. followers) (n=158)

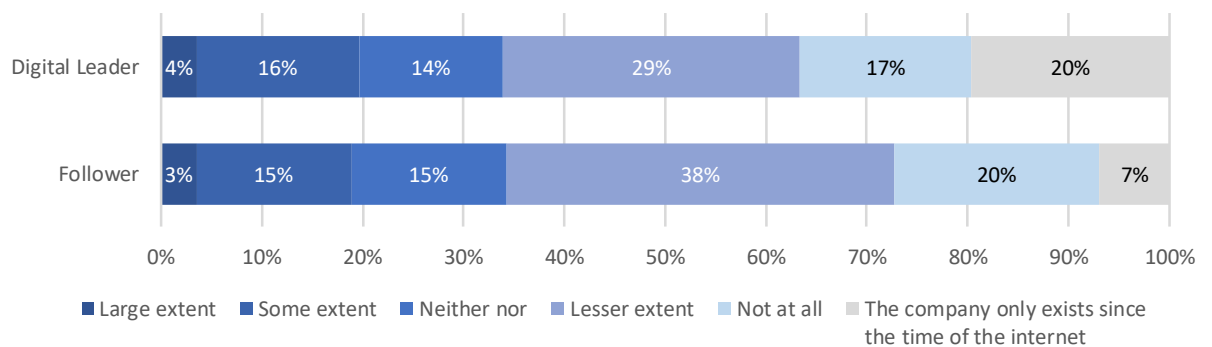


Figure 132: To which extent will blockchain affect the corporation's business in a similar manner as it was experienced with the internet? (digital leaders vs. followers) (n=255)

Causal Analysis of Relationships Regarding Blockchain in the Danish Economy

In addition to the descriptive analysis of the survey data, analytical measurement models were developed using structured equation models to analyze causal relations why companies assimilate blockchain technologies, and what are the drivers and barriers for doing so. The research applied a partial least squares path analysis on two different models. The first research model conducted focused on blockchain assimilation mediated by the degree of digitalization of a company, while the second analyzed the direct effects on blockchain assimilation.

The aspects regarding Danish companies we investigated through the survey are:

- **Blockchain Assimilation:** it represents to which extent the company is working with blockchain technology, i.e., if the company investigates, plans to apply or implemented any blockchain solution;
- **Digitalization Level:** it represents to which extent the company is a leader in the use of IT and the amount of effort the company is investing in improving its digital position;
- **IT/Business Alignment:** it represents to which extent the company's IT strategy is aligned with the business strategy;
- **Innovation Environment:** it represents to which extent the company accepts innovation coming from research in its business and the strength of encouragement from management for innovative ideas;
- **Enterprise Performance:** it represents the current and expected performances of the company in terms of number of employees and revenue;
- **Market Climate:** it represents the company's availability of qualified workforce and service providers based on its location;
- **Top Management Blockchain Know-how:** it represents how deep the insight of the top management is regarding how blockchain solutions can be used to create new products and services, improving existing processes and if or how competitors are using blockchain solutions.

The purpose of the first model is studying what are the aspects that influence a higher level of blockchain assimilation, considering the digitalization level of a company as a mediator variable, i.e., it is assumed that the digitalization level, e.g., of a digital leader or follower, governs the nature of the relationships among other aspects of a company and its level of blockchain assimilation.

On the other hand, the purpose of the second model is to study how blockchain assimilation is directly influenced by other aspects of a company. Each aspect in the context of a partial least squares path analysis is called latent variable and it is illustrated in the model as a construct with several items depicted as a circle. In addition to the path analysis, we conducted statistical tests to ensure the statistical significance of the output, which is illustrated in Figure 134 and Figure 136. Note that the higher the statistical indexes reported on the arrows, the higher is the statistical significance of the respective causal relationships.

The main outputs of the path analysis results are the strengths of the causal relationships (or path coefficients), that are indicated on the arrows among latent variables, and which represent the effect of one latent variable on another one, e.g., the effect of digitalization level on blockchain assimilation. This value may be positive or negative, that means respectively “the more is the first variable, the more is the second variable” and “the more is the first variable, the less is the second variable”.

The first path model analyzes how IT and business alignment, innovation environment, enterprise performance, market climate, and top management blockchain know-how influences the digitalization level of a company, while it also shows how subsequently the digitalization level is influencing the resulting blockchain assimilation.

Since all strengths of the causal relationships should be positive, the higher the values of the constructs on influencing the digitization level, the higher the level of digitization is, and subsequently, the higher is the assimilation level of blockchain. The most relevant causal relationships that has been found in this study is the positive influence of IT and business alignment and innovation environment on the digitization level. In other words, a digital business strategy in combination with a positive and innovation friendly environment is the strongest driver for achieving a high level of digitization. Subsequently, the results indicate that the higher the degree of digitization, the higher is the assimilation level of blockchain (Figure 133).

The second path model analyzes shows how IT and business alignment, innovation environment, digitalization level, enterprise performance, market climate and top management blockchain know-how influence the blockchain assimilation.

In this case the most relevant causal relationship according to numerical insights exhibits that the more is the top management blockchain know-how, the more is the blockchain assimilation (Figure 135). In other words, the blockchain assimilation of a company is mostly due to the know-how and the initiative of the top management.

The statistical test we executed confirms the statistics significance of the PLS Path Analysis output. For example, in the case of the first model the strength of the causal relationship between digitalization level and blockchain assimilation is 0.148, while its statistics significance is 3.091. The higher are these numbers, the stronger and the more statistically significant is the respective causal relationship.

In a similar way, the strength of the causal relationship between IT and business alignment and digitalization level is 0.423, while its statistical significance is 8.926.

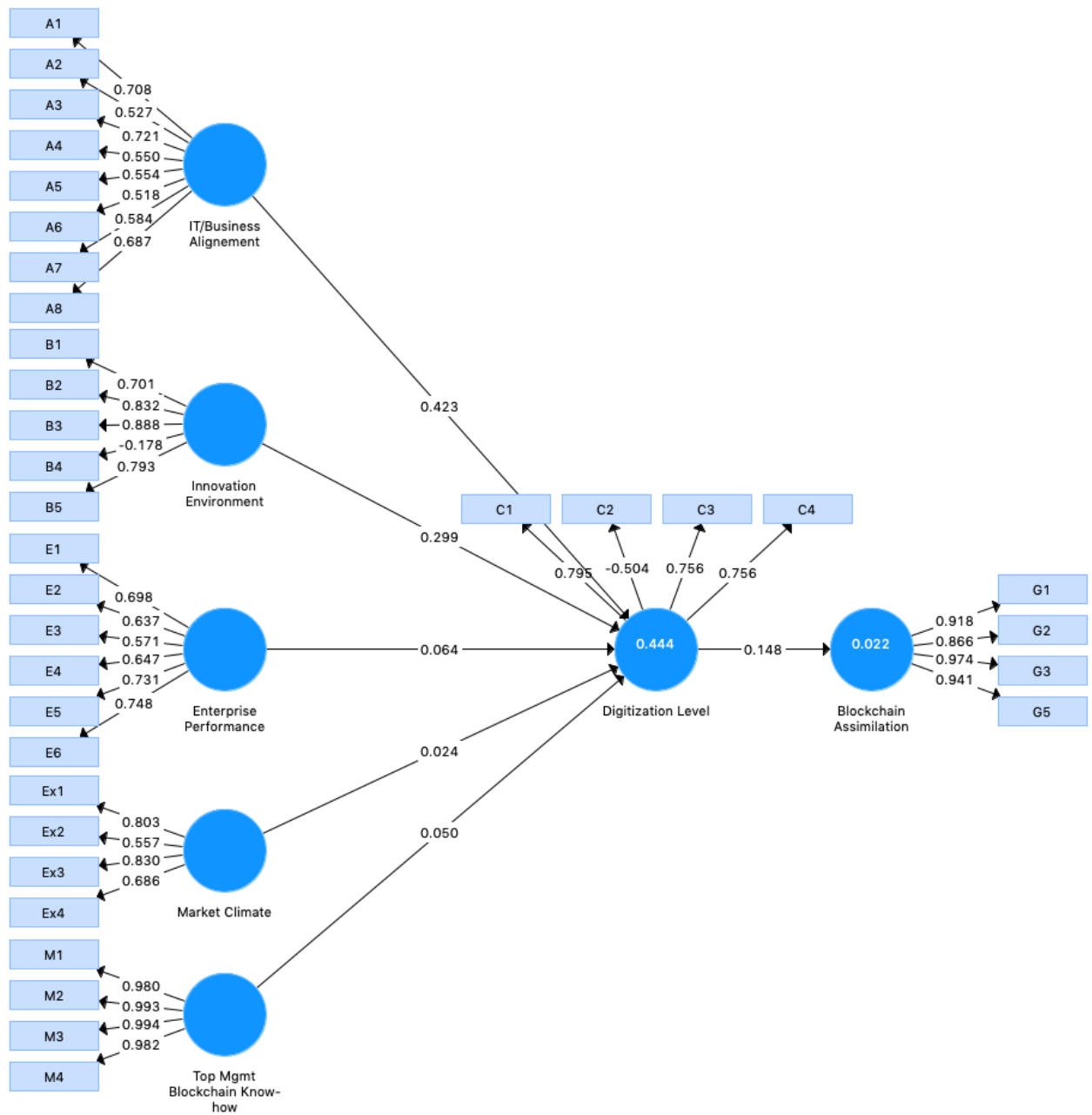


Figure 133: PLS path analysis on model “blockchain assimilation mediated by digitalization level”

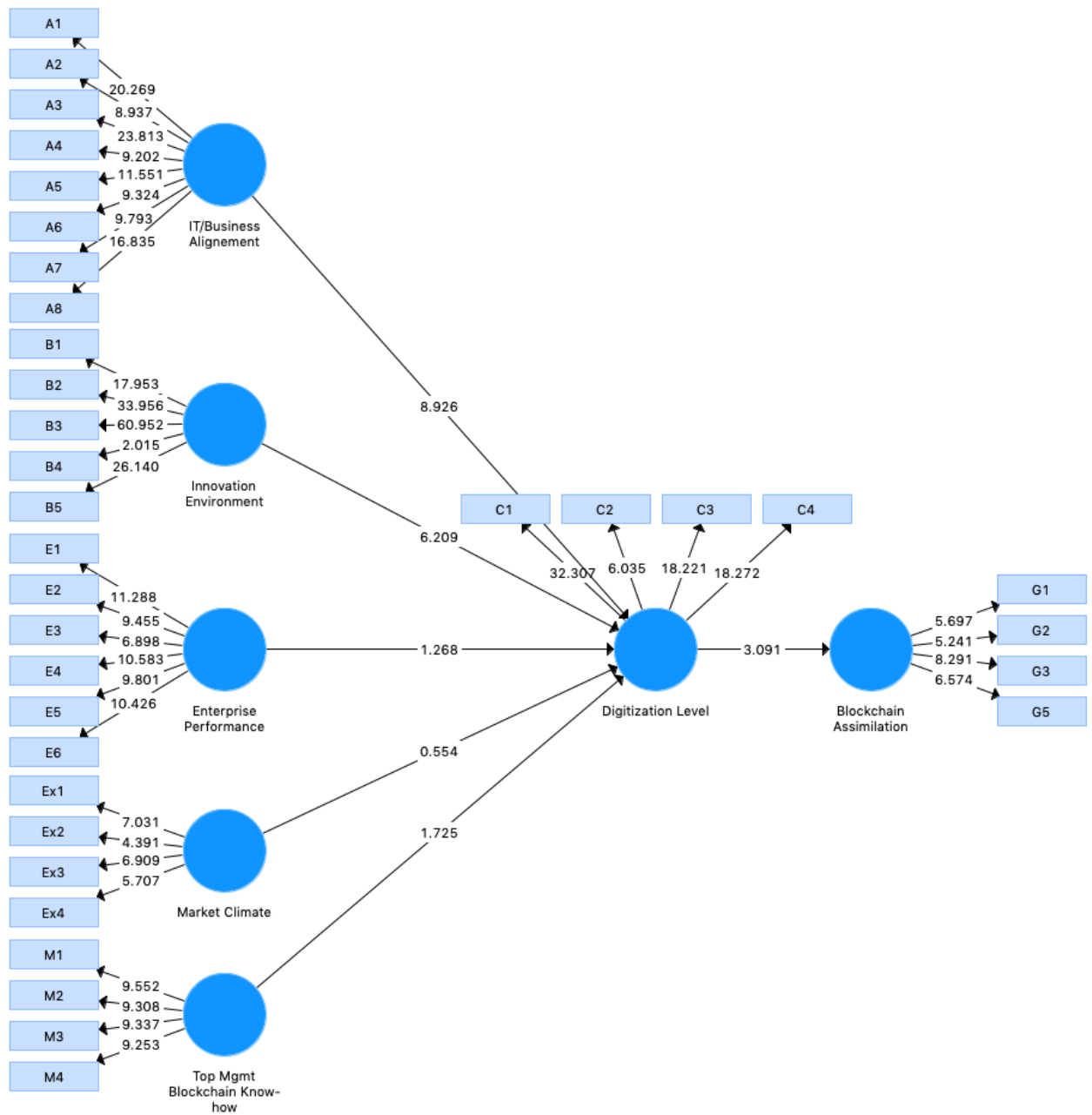


Figure 134: PLS Path analysis and statistical test on model “blockchain assimilation mediated by digitalization level”

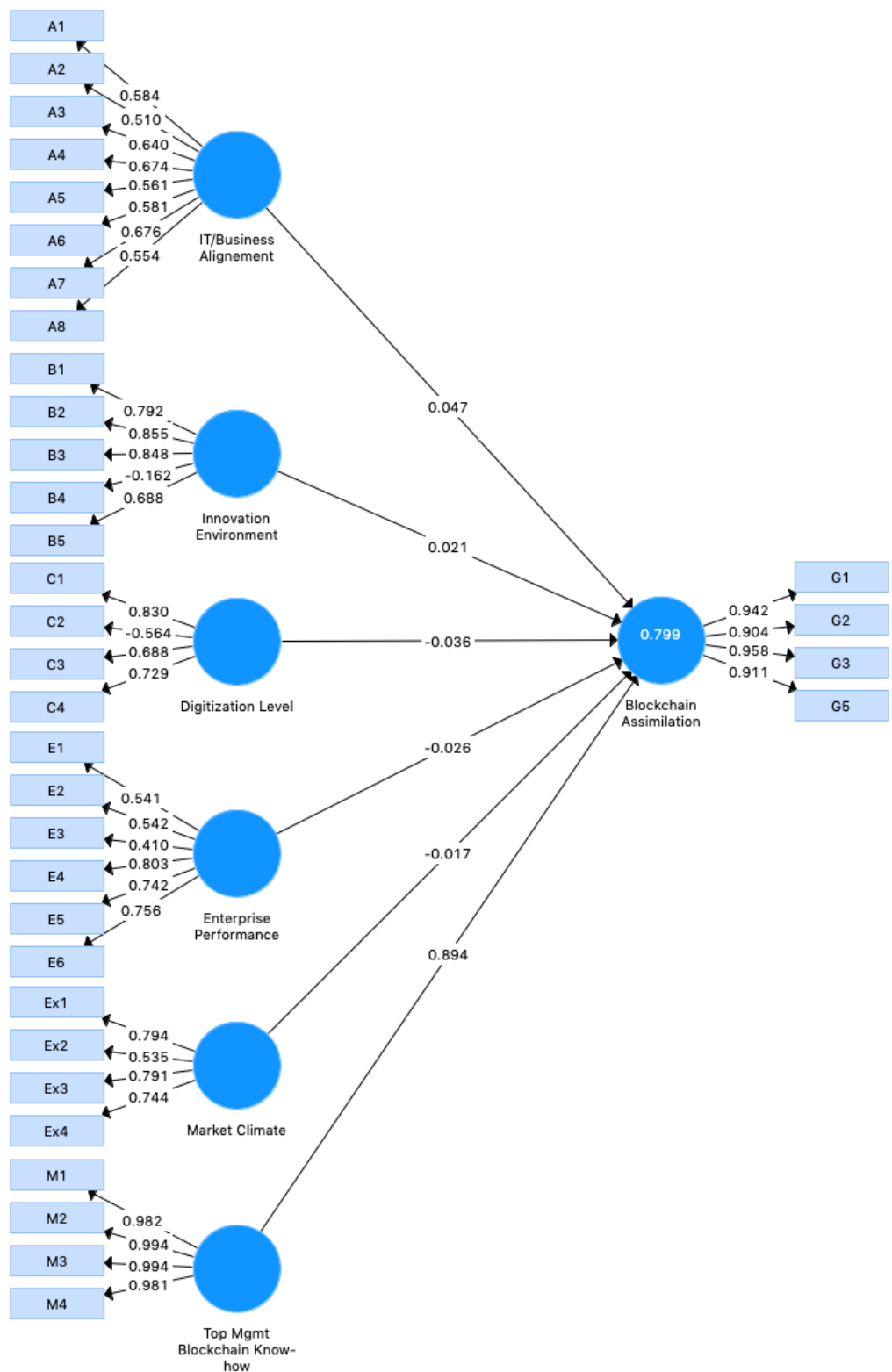


Figure 135: PLS path analysis on model “direct effects on blockchain assimilation”

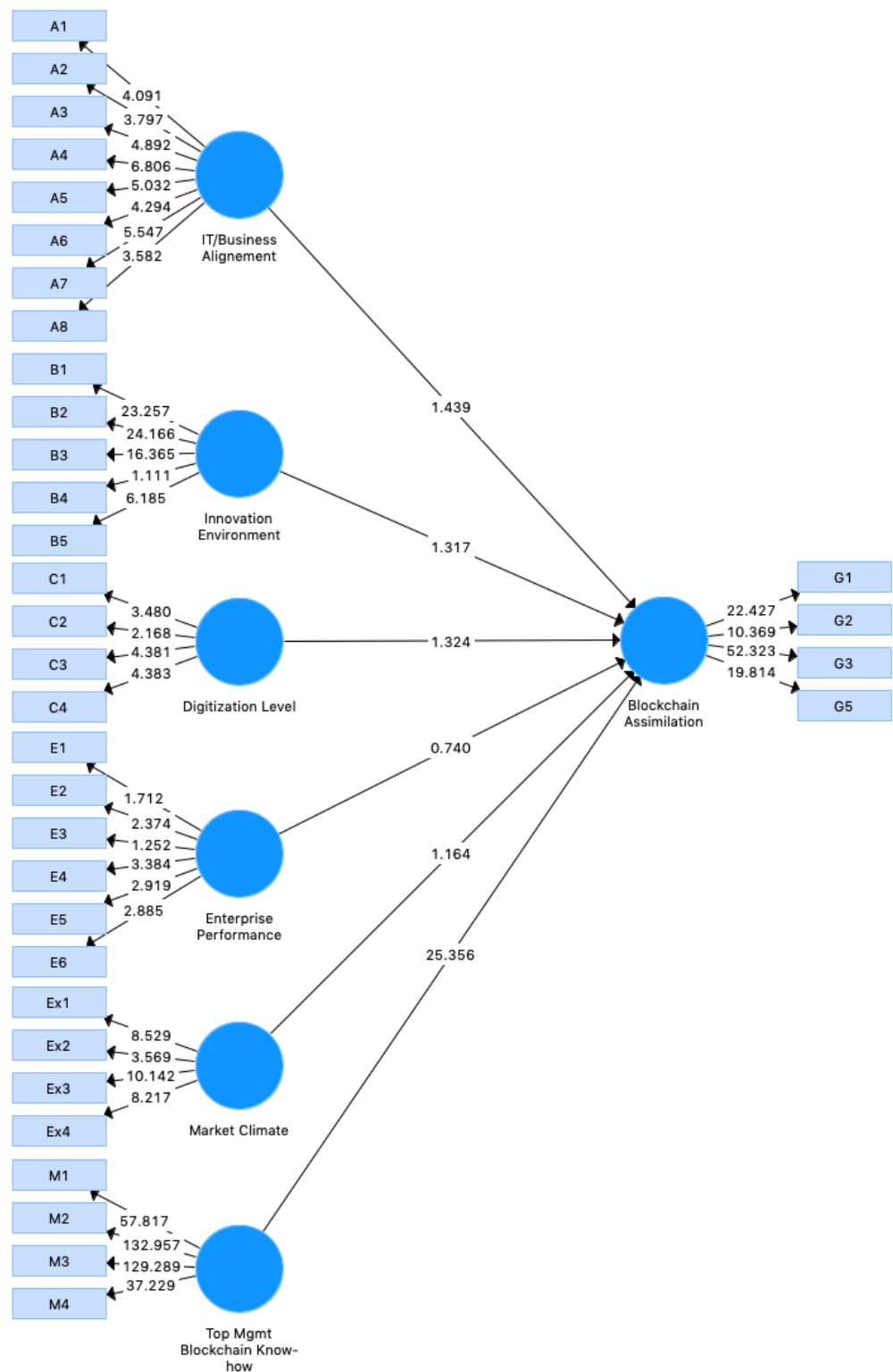


Figure 136: PLS path analysis and statistical test on model “direct effects on blockchain assimilation”

The following plots represent the strength of causal relationships of the first model.

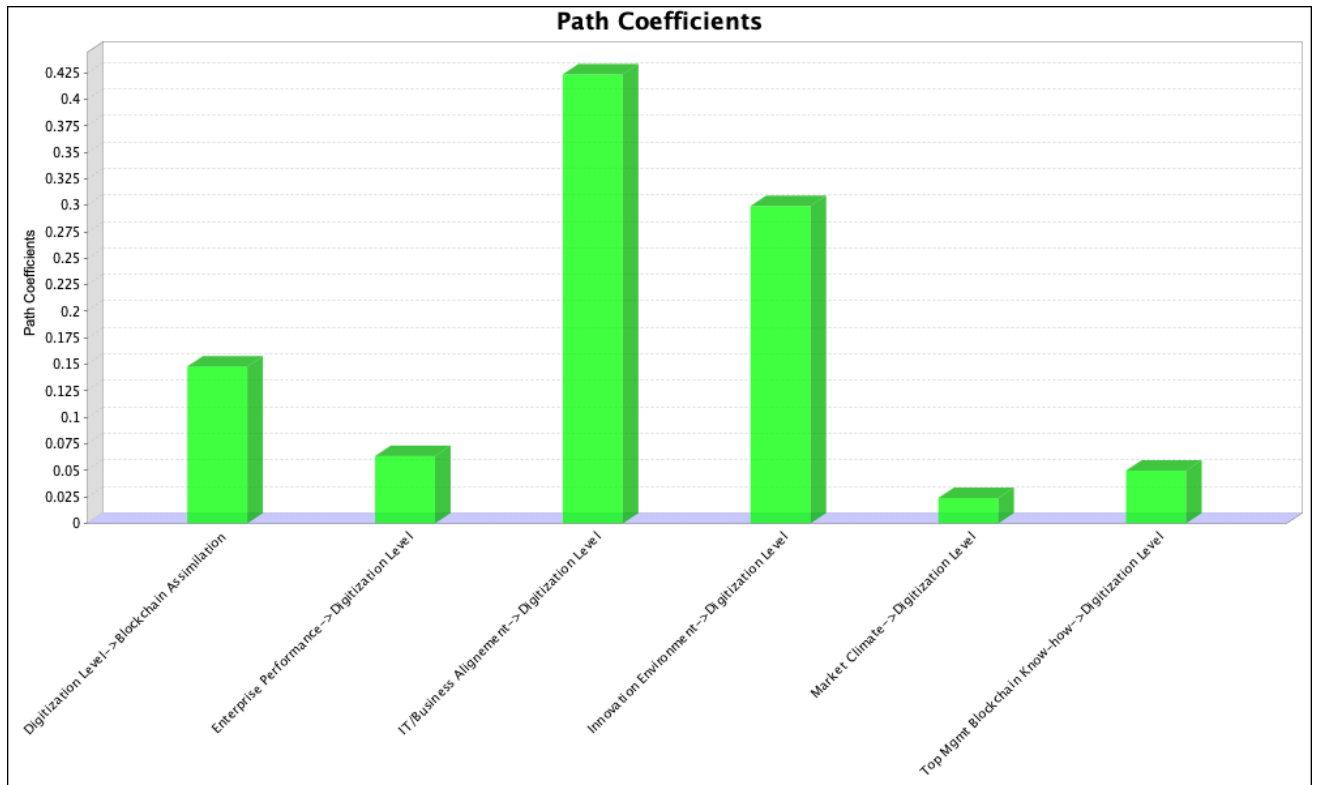


Figure 137: Path coefficient values of model “blockchain assimilation mediated by digitalization level”

Comparative analysis of relationships strengths among subsets

In this section, in a similar way to the rest of the document, we want to compare the causal relationship across the whole population of Danish companies and subsets of the population. In particular, the subsets we considered are:

- Blockchain digital leaders;
- Blockchain digital followers;
- Blockchain strong innovators;
- Blockchain innovation followers;
- Blockchain top performers;
- Blockchain performance followers;
- Blockchain high knowledge;
- Blockchain low knowledge;

After the data has been refined, most subsets still comprised a large-enough data sample to execute the analysis. The subsets that did not preserve a big enough volume of data have been excluded by this comparative analysis. In some case it was possible to execute an analysis on a subset, but some latent variables could not be described anymore by observed variables and they have been excluded by this comparative analysis as well.

The following tables compare the behavior of the whole population of Danish companies and the subsets listed above, according to the previous models: “blockchain assimilation mediated by digitalization level” and “direct effects on blockchain assimilation”.

Blockchain Assimilation mediated by Digitalization Level												
Dataset	Strength of the causal relationships (Path Coefficients) and Statistical significance (T - Statistics)											
	Digitalization Level → Blockchain Assimilation		IT/Business Alignment → Digitalization Level		Innovation Environment → Digitalization Level		Enterprise Performance → Digitalization Level		Market Climate → Digitalization Level		Top Mgmt Blockchain Know-how → Digitalization Level	
Population	0.148	3.091	0.423	8.926	0.299	6.209	0.064	1.268	0.024	0.554	0.05	1.725
Blockchain Digital Leaders	0.215	3.174	0.385	3.28	0.077	0.615	0.168	1.731	0.255	1.135	0.009	0.139
Blockchain Digital Followers	0.151	1.825	0.368	6.059	0.313	5.284	0.099	1.589	0.03	0.51	0.04	0.878
Blockchain Strong Innovators	0.2	1.019	0.51	7.286	0.153	1.909	0.114	0.76	-0.012	0.132	0.106	1.48
Blockchain Innovation Followers	0.139	2.761	0.384	8.05	0.348	6.393	0.043	0.774	0.058	1.044	0.065	1.587
Blockchain Top Performers	0.274	6.576	0.422	5.986	0.332	4.35	-0.02	0.273	0.036	0.508	0.104	2.665
Blockchain High Knowledge	-	-	0.467	5.36	0.285	2.643	0.15	2.12	-0.061	0.534	0.064	0.768
Blockchain Low Knowledge	-	-	0.436	9.45	0.299	5.64	0.049	0.951	0.031	0.644	-	-

Figure 138: Comparison of blockchain assimilation mediated by digitalization level among subsets

Direct effects on Blockchain Assimilation												
Dataset	Strength of the causal relationships (Path Coefficients) and Statistical significance (T - Statistics)											
	IT/Business Alignment → Blockchain Assimilation		Innovation Environment → Blockchain Assimilation		Digitalization Level → Blockchain Assimilation		Enterprise Performance → Blockchain Assimilation		Market Climate → Blockchain Assimilation		Top Mgmt Blockchain Know-how → Blockchain Assimilation	
Population	0.047	1.493	0.021	1.317	-0.036	1.324	-0.026	0.74	-0.017	1.164	0.894	25.356
Blockchain Digital Leaders	0.043	0.274	0.014	0.198	0.11	1.556	0.089	1.737	0.109	1.277	0.7	9.622
Blockchain Digital Followers	0.031	1.822	0.002	0.175	-0.029	1.723	0.039	1.082	-0.022	1.747	0.962	51.972
Blockchain Strong Innovators	0.013	0.103	0.067	0.886	-0.02	0.31	0.092	0.943	0.085	0.797	0.669	8.548
Blockchain Innovation Followers	0.052	1.349	0.023	1.122	-0.046	1.37	0.02	0.392	0.013	0.494	0.848	9.894
Blockchain Top Performers	0.004	0.067	0.056	1.382	0.038	0.949	0.046	0.82	0.006	0.116	0.775	12.269

Figure 139: Comparison of direct effect on blockchain assimilation among subsets

The comparative tables adopt a color scheme to highlight the most relevant causalities in terms of strength and statistical significance. In the case of strength of causal relationship, the darker the green color is, the stronger is the causal relationship. In a similar way, in the case of statistical significance, the darker the green, the more statistically significant is the respective causal relationship.

Note that in most of the groups the behavior of the whole population is replicated i.e., the more are IT and business alignment and innovation environment, the more is the digitalization level. The more is the digitalization level, the more is the blockchain assimilation and the more is the top management blockchain know-how, the more is the blockchain assimilation. The main difference among the subsets is related to the strength of the causal relationships.

In the case of blockchain performance followers, the remaining data after data cleaning does not allow to derive any statistically significant relationship from any model.

In the case of the blockchain high knowledge and blockchain low knowledge subsets, the remaining data after data cleaning allows to derive statistically significant relationships from just the first model.

The most significant insights from this comparative analysis are the following:

- In the case of blockchain top performers the digitalization level of the company influences the most the blockchain assimilation with respect to all other subsets. It can be interpreted as follows: excellent company performances and a high digitalization level are prerequisites of high blockchain assimilation.

- The IT and business alignment of the company influences the most the digitalization level in the case of blockchain strong Innovators. It means that if IT and business strategies are strongly aligned, then the companies who are more open to innovation, exhibit a higher digitalization level.
- The subset of blockchain digital followers is the one in which the top management blockchain know-how influences the most the blockchain assimilation. It can be interpreted as follows: in the case of companies who are not leader from a digital point of view, the blockchain assimilation is mostly and especially due to the know-how and the initiative of the top management.

D COMPARATIVE ANALYSIS OF THE EFFECTS OF BLOCKCHAIN ON DIFFERENT COUNTRIES

This section extends the scope of the analysis beyond Denmark to observe the potential effects and strategies in the context of blockchain in different selected economies around the world. This will assist in providing a larger perspective of the potential impact of blockchain on the Danish economy as well as strategies and lessons learned from other countries or regions of the world.

For each country or region, our analysis focuses on the areas public sector, private sector (startups, companies and private sector initiatives), other initiatives such as NGOs, particularly prominent industries in the respective company and ends with a brief summary and conclusion.

Global perspective

Prior to looking into examples from specific countries, it should be noted that blockchain solutions like Internet-based solutions are naturally inherently global, i.e., they can be accessed by from anywhere. This obviously challenges the notion of jurisdiction. But it is also an inspiration as a solution implemented in one area can be ported to other areas. One example is the very early land registration on blockchain in Georgia (Shin, 2017). This idea has spread so today at least Brazil, India, Russia, Sweden, Ukraine and United Kingdom are seriously launching land registration systems (Miller, 2017) with far more opportunities in countries in the developing world (The World Bank, 2018).

This may not sound so revolutionary, but land registration is considered by Don Tapscott and Alex Tapscott “Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World” in 2016 as THE key blockchain application that will change most for most people globally (Tapscott & Tapscott, 2016). Another significance here lies in that ideas of good use-cases spread rapidly.

Another global angle is expressed in a recent Forbes article on billion-dollar companies utilizing blockchain (del Castillo, 2019). Keeping a global perspective, it should be noted that IT services in general – also not blockchain-based of course – are readily available at a global scale for Danish corporations as well as for private persons. This is the business model basis for Bitcoin, Blockshipping’s container registry, MakerDAO’s stablecoin just to name a few that these services. This globality makes the notion of specific nationality of a service much less relevant if the service is readily available everywhere.

Australia

Australia has taken a strong initiative on putting their mark on the global standardization of blockchain, by leading the International Standard Organization's technical committee on blockchain and having a government that has published numerous reports investigating the potential of blockchain. In addition to that they have universities that made the top lists for blockchain programs. With that, the private sector has shown their initiative, especially in the banking sector and the activities done by the Commonwealth Bank, or leading Australian startups like Powerledger for the energy sector. On top of that, Australia has been named the 5th freest country in the world in 2019, which considers rule of law, government size, regulatory efficiency, and open markets. Having a robust free market definitely drives opportunity and growth for innovation and entrepreneurial development, which are only a few of many factors that provide a noble environment for blockchain development (The Heritage foundation, 2019)

Public Sector Initiatives

Government Participation and Standards

The Australian government has been ambitious and open to ensuring that blockchain/ DLT has an environment to flourish and develop. They have been very active and a strong contributor to the global blockchain standardization initiatives. In 2016, Standards Australia submitted a proposal (New Field of Technical Activity (NFTA) at the Australia for the International Organization for Standardization (ISO) that would start the initiative to build standards that support blockchain technology. With that, it the proposal led to the creation of ISO/TC 307, blockchain and Distributed Ledger Technologies after the suggestion of having an ISO technical committee responsible for just that. In addition, the proposal was accepted, and Australia now manages the Secretariat of the ISO/TC 307. This is committee meets bi-annually and has even managed to establish separate study groups that focus on specific use cases and interoperability. Along with that, they produce research on supply chain and trade among other topics (Horner, 2017).

“Leading the ISO blockchain committee will place Australia in the perfect position to help inform, shape and influence the future direction of international standards to support the rollout and deployment of blockchain technology. This exciting initiative will put Australia at the center stage of global innovation and digital disruption, “Standards Australia CEO, Dr Brown Evans (Stingemore, 2016).

In addition, the first international blockchain standards meeting was held in Sydney Australia in April 2017. The main outcomes of this event was the creation of a survey, workshop, and Blockchain Standards Roadmap Recommendations Report (Marquardt, 2016) .The first international blockchain standards meeting consisted of 33 member nations, such as, Denmark, Germany, United Kingdom, Japan, France, Russia, Singapore,

China, USA, etc. In Figure 140, there is a timeline review that highlights activities that the ISO/TC 307 blockchain group has done.

Date	Activity	Result
April 2016	Submitted a Proposal for a new Field of Technical Activity at the International Organization for Standardization	Establishment of the new ISO technical Committee for blockchain (ISO/TC 307)
September 2016	Management of the Secretariat of the ne Technical Committee for blockchain	Host the first international blockchain standards meeting in April 2017
March 2017	Creation of the Roadmap for blockchain Standards report	Summary of findings and foundation reference point for future work
June 2018	Bi Annual Workshops and Study Group work on various topics from the TC for blockchain	Held an industry roundtable for business in New South Wales, Australia

Figure 140 Standard Activities for ISO/TC 307 blockchain reported by Standards Australia

With that, in 2017 the roadmap for blockchain standards report in Australia provides many interesting facts about what the respondents from a wide variety of fields desired. Regarding various government services that could be optimized, survey respondents stated that they would like to see blockchain technologies to improve efficiencies and public access with Land Transfers and Property Title Registrations (72 percent), Personal Identification and Passport Documentation (68.9 percent), and Management of Health Records (65.6 percent) being the top three services that were desired to be improved by blockchain (Standards Australia, 2017).

Research

In blockchain research, Australian universities are among the leading institutions in the world. In a 2018 ranking of world's best universities for blockchain or cryptocurrency studies, the Royal Melbourne Institute of Technology (RMIT University) came in 20th as the best in the world (CEO World, 2018). With that, the Australian government also announced the deployment and use of a blockchain-based SAAS platform, which is provided by AUCloud, as a software-as-a-service cloud platform. It will be used by major Australian government departments such as its Defense Department as of December 2018 (ConsenSys, 2019).

The Australian Government's National Innovation Science Agenda (NISA) and the Treasury has conducted a study on scenarios for the Australian economy regarding Distributed ledgers. The governmental report does provide insight to a Public sector perspective of

what factors are important in observing the influences and potential changes this technology could have on a macroeconomic scale. It pointed out two fronts that it observed in the report; observing future productivity growth in new or existing industries and the overall development of companies and new industries that could result from this new technology (Hanson, et al., 2017). With that, the report has a counter report that considers the risks and opportunities for systems using blockchain and Smart Contracts. The report observes four use cases for both the public and private sector.

The report concludes comprehensive challenges seen on an implementation level that expanded past the general technical risks and limitations. The challenges observed were; Concentration of Power, Consumption of Power, Toxic Data, Computer Processing Power, Lost in Translation, Interoperability, and Scalability and Performance. Regarding to Toxic Data, it specified in more detail the issues of having a permanent ledger that one has issues of deleting or adjusting data. First, the blockchain bloat, the more transactions there are the larger the blockchain will become that will increase its 'bloat' which will decrease the utility and decrease performance making it less every-day user friendly. Second, Data Spill, which focuses on the challenge that if a piece of data becomes 'illegal, unconscionable, classified, or otherwise' there is no way to get rid of it on a ledger. This causes more legal challenges in the occurrence of regulation changes, such as, The Right to be forgotten that EU citizens have (Hanson, et al., 2017). The third example of Toxic Data was 'Needle in a 'block-stack', which refers to the constant generation of data without a sufficient organizational system then it could get to the point where information is not known of what is available and what is not.

Overall, Australia has shown to have a very active public sector that has taken the initiative to create a positive environment for the private sector as well as set an example as a global player in blockchain applications, especially with their contribution to the International Standard Organization.

Startups, Companies and Private Sector Initiatives

Startups

As the Australian government has decided to increase its financial efforts into developing a national blockchain roadmap (March 2019), in order to position Australia as a hub for blockchain Technologies. The Medici Media Group focused on Fintech summarized a list of the top 17 Australian blockchain Startups to watch for in the FinTech realm, five startups to be highlighted are the following; blockchain Global, Vennd.io, Havven, ChronoBank, bron.tech, Paperchain. Blockchain Global was founded in 2014 and has 4.9 million dollars in funding. It was originally called Bitcoin Group however adapted to the market and changed its name in 2016. They are a bitcoin mining operator, operates a portfolio of mining machines and provides a consultancy service that is called 'BitTechnology', and has an incubation hub/fund called Bit Fund as well. With that it is also publicly listed. In addition, ChronoBank was founded in 2016 and has raised 5.4 million for leveraging blockchain to provide a cryptocurrency wallet and cryptocurrency exchange services that help Human

Resources, Recruitment, and Finance Industries to transact in crypto. Aside of that Havenn has raised over 250 thousand and has only been founded in 2017 (Team, 2019).

With that, the blockchain community BITFWD community, which has partners such as Coindesk, UNSW, HiBlock Community, Olympus Labs, and NEM produced an overview of the Australian blockchain ecosystem (Terado, 2018) reflects on the progress that Australia’s blockchain ecosystem has made since 2017. They summarized the by listing 124 different active organizations in various areas that are blockchain focused as one can see in Figure 141. One can observe how communities as well as Development/ Consulting hold the largest groups of blockchain related organizations. The organizations are very diverse from having some in Voting & Identity, to Agricultural, and Health. With that, as to be expected the Financial and Exchanges or Trade blockchain organizations are also at having 10 or more organizations that are focused on these topics of interest.

One of the largest banks in Australia the Commonwealth Bank of Australia has joined the initiative to work with other banks to find applications of blockchain technology along with many other banks across the world. However, as observed in the start-ecosystem in Australia, there are many areas beyond the financial industry that are applying or open to blockchain (Figure 141).

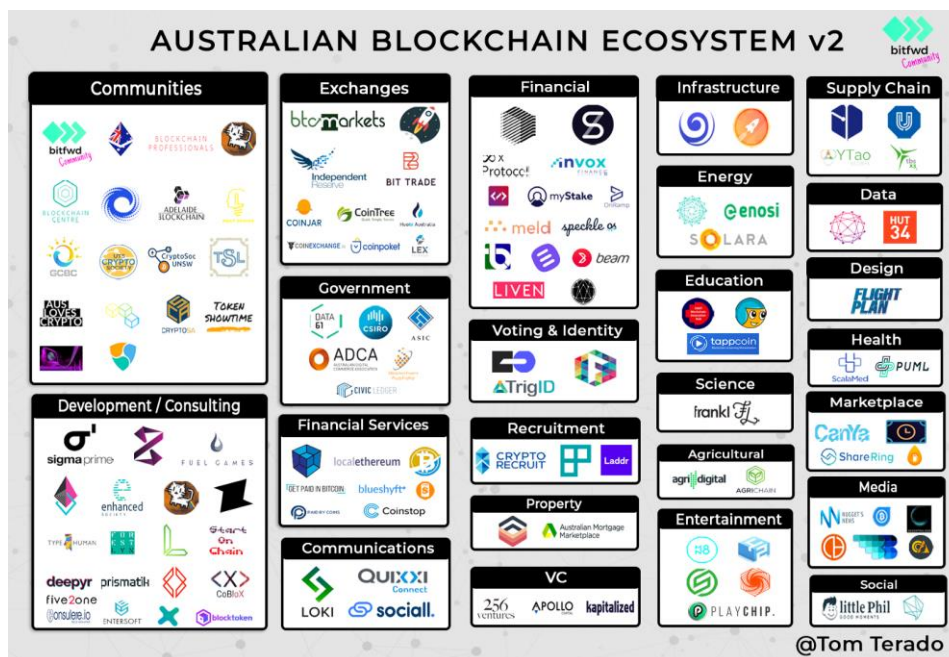


Figure 141: Australian blockchain ecosystem from BitFWD community (Terado, 2018)

Private Sector initiatives and Companies

As for Private Sector initiatives and Companies, they are focusing as a whole on the importance of understanding the effects of a digital economy, issues relating to digital disruption, knowledge-based industries and the innovation system. The Commonwealth

scientific and Industrial Research Organization created a report on these topics specifically related to the impact of Distributed Ledger technology and blockchain in 2017 (Organization, 2017). While Financial Services are still leading in blockchain applications, other private sectors such as the energy sector has peaked great interest in blockchain after the success of Australian start-up Power Ledger. The success of Power ledger has led to seven other projects implemented in Australia include the Greenwood Solutions, the White Gum Valley, National Lifestyle Villages, RENew Nexus, Evermore, Origin Energy and Vicinity Centers Castle Plaza in the energy sector.

Aside of that the ASX, Australian Securities Exchange, became one of the first major trading exchanges to announce addition of blockchain technology, where they developed a concept of post-trade platform based on DLT that recorded shareholding, management the cleanings and settlement of equity transactions.

Other Initiatives

In January 2018, the World Wildlife Federation has established a project looking into the use case for blockchain as a solution for illegal fishing and human rights abuses. This would in turn help consumers know if the tuna they are eating are from illegal operators among other examples. The use case would be able to reveal where and when fish was caught, by which vessel and the method. It is a project including three countries of the WWF, ConsenSys, TraSeable, and Sea Quest Fiji Ltd (ConsenSys, 2019). The Brisbane International Airport was awarded the World's First Crypto Friendly Airport in 2018 (ConsenSys, 2019).

Industry Focus

The leading industry in Australia that are adopting blockchain technologies are the Financial Industry. For instance, the Commonwealth Bank of Australia has created a new blockchain platform, which integrates DLT, smart contracts, and IoT, that demonstrated how to implement a shipment of seventeen tones of almonds from Australia to Germany. Along with this demonstration, the very active Commonwealth bank and five other supply chain leaders were able to track the process from start to finish (ConsenSys, 2019). Other leading industries according to a report by law firm King & Wood Mallesons are that blockchain technologies are most notable in the 'financial services, government, and supply chain management (particularly agriculture)' (Bitcoin Australia, 2018).

Conclusion

The Australian Government is taking a great initiative on trying to get ahead and become one of the founders in standardization of blockchain technologies. As an example, it is leading the International Standard Organization technical committee on blockchain that has

biannual meeting with participants from leading countries all around the world. With that CSIRO has been active in producing studies on investigating the potential of blockchain beyond bitcoin and how it can be seen as a noble way of improving governmental services. Aside of that, the financial industry and in particular the Commonwealth Bank has been active internationally with other banks and companies in other industries, such as supply chain, to insure to push the development of this technology and its potential.

Canada

Canada is argued to hold many necessary resources needed in order to establish a global blockchain hub, some of which are having low energy costs, high internet speed, and a government that is ahead on innovation (Ozelli, 2018). With that, the founder and inventor of Ethereum blockchain, Vitalik Buterin, calls Canada home. As Ethereum is one of largest platforms for blockchain technology used today, it could be expected that Canada would use this opportunity to try to become a hub for blockchain innovation.

Public Sector Initiatives

The Canadian government, being in the top 10 list of freest countries in the world (The Heritage foundation, 2019), has proven in motivation to ensure an environment that helps encourage the investigation and use of new technologies and innovation, such as blockchain.

Research & Government Initiatives

The National Research Council (NRC), Canadas Industrial research Assistance Program (NRC-IRAP) has experimented with blockchains technology as a demonstration for how a public blockchain is used in with governmental data, further the technology is used in a way to organize and disseminated public data about its current activities and companies involved (Engelhardt, 2017). In detail, the NRC teamed up in January 2018 with Bitaccess by using their product the Catena Blockchain Suit, which is a software for public institutions to publish complex databases on a blockchain. Further, the NRC is using it as a means to publish grants and other contribution data (Bitaccess Inc., 2018). An update of the project was provided in August 2018, where the Government of Canada are exploring additional use cases and reported to now to try an explorer application, which is similar to a search engine that allows users to search easily through the blockchain for the afore mentioned grants and contribution information (BitAccess Inc. , 2018). The National Research Council Canada announced in their 2019-2019 Departmental plan, which included the continuation of the use cases with a longer-term view of applying this technology to other use cases and to continue with the adoption across other areas in the Government of Canada (National Research Council Canada, 2018-2019).

“Our goal is to enable institutions to become fully transparent, and enable constituents to participate in the verification and validation of public information” stated by Moe Adham, co-founder of Bitaccess (Bitaccess Inc., 2018).

Information and Communications Technology Council (ICTC) of Canada teamed up in 2017 with ColliderX, The Blockchain Association of Canada, the Blockchain Research Institute, and Blockchain Canada to develop a nationwide blockchain ecosystem that has the goal by 2024 to have Canadas blockchain market to reach 2.5 billion (CAD) and to create 107,700 jobs (Information and Communications Technology Council of Canada, 2017).

Startups, Companies and Private Sector Initiatives

Startups

Canada has been fortunate to have been the home country of the founder of Ethereum, one of the largest blockchain platforms in the world. With that, another impressive start-up, Bitaccess, which was founded in November 2013, offers software services that are blockchain-based for a range of clients from star-ups to Fortune 500 companies in more than 15 different countries (Bitaccess Inc., 2019).

With that, a summary of Canada’s blockchain Landscape for 2018 can be found below in Figure 142 Canadian blockchain landscape. They compiled a list of over 200 startups, Venture Capitalists, and blockchain related entities. They grouped the landscape into eight categories; Fintech, Sovereignty, Value Exchange, Developer Tools, Professional Services, Cryptocurrency Mining, Venture Capital, and Other (Futoriinsky & Singer, 2018). Some of the top takeaways that was summarized by (Futoriinsky & Singer, 2018) that the growth was slowing as they observed that that from 2013 till 2017 that there were 200 blockchain entities that entered the system and in 2017 alone there was 90 entities that join, however, in 2018 there were only 26 entities that join. They observed that about 32 percent of Canadian blockchain companies are focused on Fintech and on opportunities in Payments & banking, Trading, Exchanges, and wallets (Futoriinsky & Singer, 2018). The three big blockchain industry players that was founded in Canada are Ethereum, Aion, and ConsenSys, that play an important role on a global level.

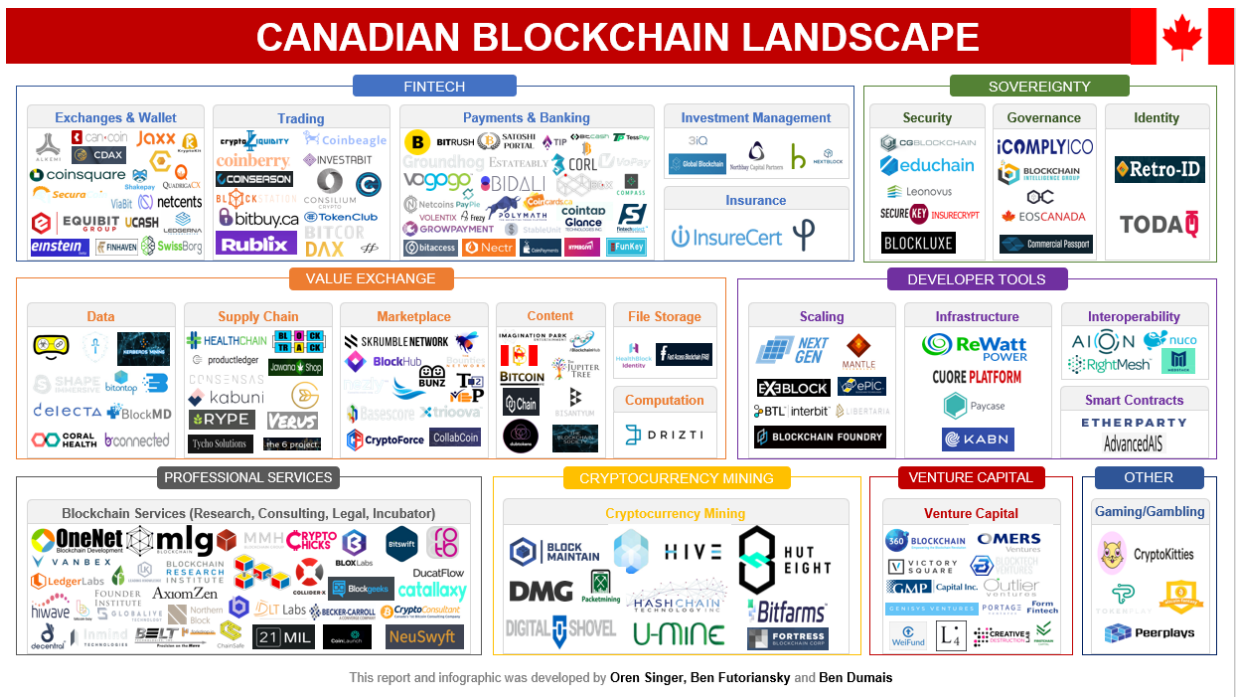


Figure 142 Canadian blockchain landscape (Futuriansky & Singer, 2018)

Private Sector

While financial services sector has the most action and interest into blockchain, the Chartered Professional Accountants Canada published a report that investigates the potential of blockchain and how it could be applied in regard to the financial statement Audit and the Assurance Profession in General. It lists the possibilities or potential opportunities that it could have with using blockchain technologies such as, optimizing the Administrator function, Arbitration Function, or the Service Auditor of the Consortium (Chartered Professional Accountants Canada, AICPA, UWCISA, 2017)

Other Initiatives

Blockchain Research Institute is an ambitious organization that is based in Toronto, Canada that was founded by Don Tapscott and Alex Tapscott after their best-selling book on blockchain Don Tapscott and Alex Tapscott *“Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World”* in 2016 (Blockchain Research Institute, 2019). They are conducting over 100 research projects on blockchain and associated technologies that focus on ten sectors that they identified as high interest such as; Energy & Power, Financial Services, Government, Healthcare, Manufacturing, Media, Retail, Resources & Mining, Technology, and Telecom. In addition to investigating the effects of blockchain on industry sectors, they are also looking into how blockchain could change corporate roles, such as; CEO: Leadership and strategy, COO: Logistics Supply Chain, CLO: Smart Contracts & Legal Applications, CCFO: Accounting & Corporate Finance, CIO:

Enterprise Architecture, CHRO; Human Resources & Credentialing, and CMO: marketing and Advertising (Blockchain Research Institute, 2019).

Industry Focus

Canada participated as one of seven countries in a study created by Deloitte US about the opinions and perceptions of blockchain and its future. Respondents from Canada reported that 73 percent expected more than 1 million dollars of investment into blockchain Technologies for 2018-2019. Overall, Financial Services industry leads the front of blockchain applications, especially in the area of wholesale payments, securities settlements, and digital identification (Deloitte, 2018).

Other industries of focus are the Supply Chain industry, one example would be regarding the supply chain management that is needed for legal cannabis industry. After the country's government legalized marijuana, the government is in search of optimizing the market and to prevent the illegal market. With that, the DMG Blockchain Solutions Inc. has announced its development of the platform to address the issues at hand (Alexandre, 2018).

Conclusion

Overall, the Government of Canada has many initiatives that are focused on encouraging development in innovation and for blockchain. The National Research Council (NRC), Canadas Industrial research Assistance Program (NRC-IRAP), has shown its motivation by demonstrating use cases and in implementing blockchain technology also on governmental databases. Canada's research in blockchain also seems to be flourishing, especially it being the head quarts for the blockchain Research Institute. The startup scene has had a few main players that have made it to the global scene, such as, Ethereum, Aion, and ConsenSys. The private sector has also been active in exploring blockchain as reported in (Deloitte, 2018) that by 2017 already 70 percent of firms invested more than 1 million in blockchain. In conclusion, isn't a surprise that Toronto, Canada has made number eight on the World's Top Ten blockchain Cities (Cohen, 2018).

China

China may be considered one of the leading countries in terms of blockchain use today. Not only because of their very high cryptocurrency activity in terms both to crypto-mining and -trading, but because half of the world's cryptocurrency transactions are estimated to come from China in comparison to 25 percent from the US and 15 percent from the EU. In addition, China (PRC) is by far the largest patent holder on blockchain patents. The single

largest entity holding patents is the Chinese Central Bank. China is emphasizing its strategic interest in blockchain from heavy participation in international standardization groups, such as, International Standard Organization (ISO). There is widespread support for blockchain initiatives with Jack Ma of AliBaba hailing “Blockchain as next frontier” (Shuiyu, 2018).

The Chinese government is promoting the development of a blockchain industry from the national level which means that provinces and cities are following suit with financial support programs and favorable conditions. The effect is clear, The People’s Bank of China has more blockchain patents than any other organization in the world. Chinese corporates like Alibaba and JD.com are rushing to develop and implement blockchain solutions and startups like NEO are developing standard blockchain solutions that they apply across different sectors and business areas.

Public Sector Initiatives

Legislation

The Chinese government is a heavy promoter of blockchain initiatives and has recently introduced a set of regulating laws to make it clearer for users and corporations to maneuver in the legal landscape (Felix, 2018). As a result, there is also heightened attention on avoiding anonymous transactions (Ogono, 2019). Further, the government has launched a recent crackdown on cryptocurrency mining, which will have an effect as 74% of the hash power on the Bitcoin network is in Chinese-managed mining pools (Hsu, 2018) (Kaiser, et al., 2018).

Administration / e-Government

A recent whitepaper (工业和信息化部信息化和软件服务业司, 2016) on use of blockchain in China has been published, which focused particularly on financial services, supply-chain management, entertainment, smart manufacturing, social welfare, education and employment. A specific example of the e-government potential is investigated and the use of blockchain-based solutions for social security payments.

Startups, Companies and Private Sector Initiatives

With the widespread entrepreneurial spirit in China, it is not surprising that almost 40 percent of the total number of all currently existing blockchain start-ups in 2017 were from China (hype.codes, 2018). Newer figures are not yet available, but the percentage is expected to increase illustrating that blockchain opportunities are taken very seriously in China.

Industry Focus

In special economic zones in China Western, (blockchain) companies are invited to establish themselves in the booming Chinese market provided they team up with a Chinese partner. Lavish economic support is promised for such activities.

Conclusion

The Chinese government is investing heavily in both blockchain initiatives and by providing commercial benefits to start-ups in the selected industry-areas. China is widely regarded as the leading blockchain country today simply due to the intensity, depth, and breadth of the activities across all parts of the Chinese society.

Estonia

Estonia has a reputation on being on the forefront of digitalization, exploring blockchain reaffirmed this motivation. Estonia already began testing blockchain technologies since 2008, even before the first Bitcoin whitepaper named the term 'blockchain'. Estonia was using this technology but named it "hash-linked time-stamping". In addition, as of 2012 Estonia's government has had operational use of blockchain in various registries in the following fields: national health, judicial, legislative, security and commercial code systems (e-Estonia, n.d.).

Public Sector Initiatives

E-Government

Estonia is praised for its drive regarding having an e-Government. As of 2018, they rank 16 in the world with leading e-government development (Nations, 2018). With that, they already have a blockchain-based solutions regarding e-voting for representatives at the community, city, and national levels. The voting system provides voters with voting-rights assets and voting-tokens, where the user can spend the voting tokens to vote (Kshetri & Voas, 2018). In addition to voting, the Estonian government also are adopting blockchain for future projects regarding e-residency to allow foreign citizens to have a business in Estonia (Kshetri & Voas, 2018). In addition, they are applying blockchain technologies in health care in order to increase security on health data storage and to have real-time monitoring of patient conditions (Kshetri & Voas, 2018) (Cointelegraph, 2017). As of 2016, it was reported that Estonia secured up to one million health records (Williams-Grut, 2016).

In order to achieve this, the Estonian Government is working with a company called Guardtime.

As a result of a cooperation between the Cybersecurity Competence Center and the Estonian Ministry of Defense and Estonian Information Systems Authority, they are reported to be working together on bringing perspectives from academia, the public and private sector together (Republic of Estonia: Information System Authority, 2018).

“Estonia has been a successful test lab for secure digital services ranging from a digital identity scheme to online voting and integration of blockchain into data integrity solutions. This new partnership allows us to further focus on our efforts on demonstrable and scalable strengths of this diverse ecosystem,” emphasized Martin Ruubel, President of Guardtime, co-founder of the association (Republic of Estonia: Information System Authority, 2018).

The government has reported in April 2019, of starting to implement a new use case regarding car accident reporting. The use case looks into that if the accident is reported and registered online, then both parties would also be informed with the outcome if all of the information was in a transparent database. (e-Estonia, 2018)

Estonia has claimed their own digital ecosystem e-Estonia, which allows for mostly all public services to be accessed digitally and it's based on blockchain (ELT Digital, Startup Wise Guys, 2017-2018). In addition, Estonia is also working together with 40 other governments around the world on their digital initiatives (ELT Digital, Startup Wise Guys, 2017-2018).

Startups, Companies and Private Sector Initiatives

Even with its small size of only 1.3 million people, Estonia is driven to having an advanced digital economy. In Estonia since 2017, they have offered a Estonian Startup Visa program to attract non-EU entrepreneurs, since then they have had over 1,000 applications from over 80 different countries (Fintechnews Switzerland, 2019). The Baltics as a whole are reported to be more active than its European neighbors in funding via ICOs, Estonia has raised funds through ICOs till 350 million euros till May 2018

One of Estonia's blockchain startups made the top ten European early stage blockchain startups list. The Tallinn based startup is called Ambrosus and was founded in 2016 as a blockchain powered IoT network for food and pharmaceutical companies (Loritz, 2019). Given the size of the country, it could be that most companies come from abroad and startups are not as fruitful as in other surrounding countries.

Companies are also benefiting from the Estonian blockchain ambition to be as technologically advanced as possible to lay a foundation that Estonian companies in the private sector can utilize and join in rather than to create the foundation themselves. It appears the leaders of innovation in Estonia go to the government to work instead of the private sector (Heller, 2017).

Other Initiatives

Estonia has many initiatives under the public sector for blockchain applications and initiatives. However, given the size in GDP and in population, the large nonprofit or NGO's are not as well represented in using blockchain in Estonia as in other countries that have a larger population.

Industry Focus

Given the size of the country and economy, the main industry focuses appear to be in ICT and the financial and insurance industry. The main sector in Estonia that is making an impact on blockchain is the public sector which had a head start even before 2008.

One example of blockchain impact in an industry in Estonia is the insurance industry. KSI Blockchain, was established by an Estonian company called Guardtime, which works together with the government in producing a lot of its blockchain applications. Guardtime is working with EY to establish InsurWave, which is a platform for different use cases in the insurance industry; such as, tax calculations, declarations, foreign exchanges, etc. (Plantera, 2018).

“By standardizing an insurance contract into structured data and implementing it as a smart contract, it's possible to eliminate large amounts of manual work relating to reconciliation and foreign exchange calculations. This ultimately will allow us to automate the netting and settlement of payments. Overall, the costs associated with the above amount to nearly 20% of gross premiums – in a multibillion dollar specialty insurance market”, the President of Guardtime Estonia (Plantera, 2018).

Conclusion

Estonia's government has the reputation of being digitally advanced and driven. This has been confirmed after exploring the involvement of various sectors and their interaction with blockchain. It appears to be clear that Estonia's government is leading the motive on innovation in blockchain, rather than the private sector as it would be expected in most other developed countries. Having such a foundation of blockchain and identity from the government, this provides companies the opportunities to also use this as a base. With that, the government is also trying to encourage new innovation from outside of the EU by even offering a Start-up visa for those who are interested.

European Union

As both one of the largest global commercial entities and a leading entity for rule-based governance, the European Union's (EU) activities are of key global interest and relevance. Specifically of Danish interest, as the EU is the main trading partner and providing the overall legal framework applied in Denmark.

Public Sector Initiatives

Legislation

Particularly GDPR regulation is interesting - General Data Protection Regulation is a regulation in EU law on data protection and privacy for all individuals within the European Union and the European Economic Area. It also addresses the export of personal data out of these areas. The GDPR legislation aims primarily to give control to individuals over their personal data and to simplify the regulatory environment for international business by unifying the regulation within the EU. Further to the jurisdiction of the regulation (EU and EEA), the GDPR regulation has sparked an intense debate globally on where to draw the rights for personal data, and what is the definition of these personal data. Also, the legislation changes several 'habits' and makes some current usage illegal (Rumbold & Pierscionek, 2017).

From a practical perspective the regulation poses several un-addressed issues. These issues are in the process of being identified in the individual countries before any major revision is envisaged.

One could argue that the aim of GDPR can be fully provided by blockchain solutions where a Global Wallet consideration could make the whole GDPR regulation redundant.

Another GDPR related aspect is the use of know-your-customer, ref. this report p.29. How much should we need to publish, to whom and for how long? This aspect has a special blockchain twist, as the proliferation of global wallets, special programs or services storing the public and/or private keys of a person and allowing tracking of ownership transfers and receiving or transferring asset ownership. The point here is that it allows each person to manage his/her personal information in the spirit of GDPR.

Administration / e-Government

The EU as a whole has established itself as a key driver for blockchain initiatives. One way that they led this initiative was by issuing a "declaration creating the European Blockchain Partnership (EBP) and cooperate in the establishment of a European Blockchain Services Infrastructure (EBSI) that will support the delivery of cross-border digital public services, with the highest standards of security and privacy." (DIGIBYTE, 2018).

One of the most active agencies on the blockchain front and application of technologies in general is the EUIPO, the agency administering the EU Trade Mark and Design rights,

applicable throughout the EU. These rights complement national intellectual property (IP) rights and are linked to international IP systems (Anon., 2019). Governance of intellectual property and intellectual assets are obvious areas for blockchain solutions, hence the agency's interest.

Other EU-agencies follow various approaches. To unite these and to „help cement Europe's position as a global leader in this transformative new technology" the European Blockchain Observatory and Forum, was launched February 2018, as an European initiative to accelerate blockchain innovation and the development of the blockchain ecosystem within the EU by working collaboratively with a broad range of stakeholders including government agencies (EU Blockchain , 2018).

Likewise several initiatives aims at benefitting from blockchain technology on specific areas like CO2 emission from truck-driving in the EU or implications for financial crime, money laundering and tax evasion (Houben & Snyers, 2018).

Startups, Companies and Private Sector Initiatives

Several EU initiatives are investigating blockchain-based projects on how to achieve benefits found from the Horizon 2020 framework program, which is a research initiative that is from 2018 to 2020 to provide more opportunities through calls for proposals to innovate with blockchain in applications for e-Government, Fintech, Next Generation Internet, IoT, Smart Homes or Media (Abeloos, 2017).

Other Initiatives

The EU is the overall legal framework for the individual countries within the union. As corporations are nationally based and registered the large number of initiatives can be found under each individual country, showing there are different emphasis dependent upon the specific country.

Industry Focus

As described above, the EU and national programs and projects cover all aspects of industry, legislation, monetary exchange e-government, FinTech, Next Generation Internet, IoT, Smart Homes or Media, (Abeloos, 2017).

Conclusion

The EU is one of the areas on the planet, where most effort is placed in investigating and launching blockchain-based initiatives often covering the whole union. Further the rule-based governance in the EU that is increasingly being automated is also a focus area on to which extent a modern civil law society can be automated (Boucher, 2017) as opposed to where governance is based on common law.

Funding: Horizon 2020

Political: European Blockchain Observatory

India

Being an emerging country, India is even more interesting to observe as has taken a role in the world as being very invested in technology skills and has a very large population. Blockchain applications are set to be very important for India's service sectors like banking, financial services, supply chain, retail, and insurance. The service sector makes up for 55.65 percent of the GDP and employs almost a third of the population (Fenech, 2018). It's further been estimated, that applying blockchain in these sectors could add up to 5 billion dollars to the Indian economy (Fenech, 2018).

Public Sector Initiatives

Legislation

The Government has banned the purchase of cryptocurrencies through Indian based bank accounts under new measures put into place by the Reserve Bank of India (RBI) in 2018. In addition to purchases, it also includes measures against banks providing services to businesses that are involved with virtual currencies. Their reasoning was that the risks associated are too high and wanted to exit the situation (Wilmoth, 2018) On the other hand, The Indian Finance Minister stated in February 2018 that while cryptocurrencies aren't recognized as legal tender, that the government does encourage the use of blockchain technologies in payment systems (Ramanathan, et al., 2018).

Coming from a developing country perspective, there are many challenges beyond adoption of technology. However, it could be that technology could help improve some challenges. It is reported that over 20 million rural families do not own land and millions more have no legal ownership, this could be seen as an opportunity for the government. With that, in 2017 India Telangana and Andhra Pradesh states want to implement a blockchain solution for land registry (Ksherti & Voas, 2018). In addition to land registries, the state is also reported into applying blockchain to use cases for transit management as

well, where the Transport Division says it wants to assign numbers for vehicles and store them on the blockchain (Navadkar, et al., 2018). Overall it was reported that around 50 percent of the states in India are trying to adopt or test out a blockchain application, where the top three use cases are land registry, farm insurance, and digital certificates (NASSCom, Avasant, 2019).

A published paper reviewed what public initiatives that India's government could benefit from by applying blockchain, some examples are the following: Health care by having a system that is more transparent, up-to-date and helps prevent fraud; Education for a registry that holds certificates and important student data, or in Public Safety as in the ability to establish a proof of different types of documents and able to prove it (Navadkar, et al., 2018). The element of trust and the transparency of blockchain could be a great opportunity for the Indian government to strengthen their authority and credibility with the people (Navadkar, et al., 2018).

Overall, the public sectors role has not been nearly as active in adopting or testing out the possible opportunities of blockchain technology as in other countries observed in this report. However, one could argue that as an emerging and developing country that the focus may not be on investing in a young technology, such as blockchain.

Startups, Companies and Private Sector Initiatives

Startups

Indian Startups in the realm of blockchain are reported to start advancing in the blockchain scene at to start teaming up with USA and UK partners. With that, they have a lot of young motivated tech people who are motivated to apply and create blockchain applications. It's expected that blockchain will disrupt industries in Finance, Governance, and Supply Chain (Manjunath, n.d.) . Three of the Startups listed on Indian blockchain Startups to watch in 2019 was Elemental, Somish, and Sofocle Technologies (Manjunath, n.d.).

It was reported in March 2019, that around 70 percent of enterprise blockchain projects are regarding regulation type business cases that deal with cost savings or operational improvements (Mathur, 2019) Further, the Banking and Finance sector has seen the highest adoption of blockchain technologies as expected, however, other industries like health care, retail and logistics are also very active with the investigation of blockchain technologies as well (Mathur, 2019).

The investments in Indian blockchain ecosystem has been low regarding global investments at a reported 0.2% (NASSCom, Avasant, 2019). Further, the report states that this low global investment into the Indian blockchain ecosystem could be due to the uncertain policy and regulatory environment (NASSCom, Avasant, 2019). Further, two of the higher investments that Indian blockchain startups received (Unocoin and Zebpay) have stopped trading due to the regulations set by the RBI (NASSCom, Avasant, 2019).

Overall, it appears that the regulatory risks that are currently in India has limited the opportunities in the private sector for both larger companies and startups as global players are more cautious in investment (NASSCom, Avasant, 2019).

Other Initiatives

An Indian Startup called Statwig, which is based in Hyderabad, India, was chosen as one of six blockchain startups to help UNICEF on their global vaccination program, which distributes around 45% of the world's vaccines worldwide. They have the initiative to make this blockchain-based (Times of India, 2018).

The Blockchain Foundation of India is a non-governmental organization that desires to serve as a neutral and unbiased platform for any entity that aims at investigating or applying blockchain particularly in India. It's a non-governmental that also identifies itself as a blockchain Network, blockchain Accelerator, and a blockchain Pioneer (Blockchain Foundation India, 2019).

Industry Focus

The three main industries of interest reported by (NASSCom, Avasant, 2019) are banking, manufacturing, and financial services. They hold about 61 percent of the revenue and have been involved in adopting blockchain services since the last 24-36 months. At 28 percent of share of revenue, the Insurance, Retail and CPG, and Utilities and Resources, and Government and non-profit are included with 12-24 months since the industries started the adoption.

Conclusion

Overall, India holds a lot of potential for blockchain use cases. However, it appears that after the ban of cryptocurrency trading that also the adoption of blockchain applications took a hit, despite the government praising the application of blockchain. With low global investments and being in the position of a developing country, the blockchain ecosystem is not as advanced as other global players involved in the advancement of this technology. Despite of this, India is still a country that seems passionate about new technologies and their applications and see the potential advantages that blockchain could make in the country. The role of India as a global player in blockchain technologies has yet to be realized.

Russia

Russia is like most of the countries described in this study, where it is open for digitization and currently making progress in applying blockchain in both private and public sectors taking on regulations and legislations that help bring the country onto the digital world arena and strongly financing the integration of new technologies, among which is blockchain, into the national processes. According to the announcement of Russian Prime Minister Dmitry Medvedev, Russia's digital economy development national program is to be funded by over 1.8 trillion rubles (US\$26.2 billion) over the next five years. The investment opportunities are seen mainly in 5G technologies, blockchain and other crypto-mechanisms (Russia Briefing , 2019).

Up to now, the state of Russia and private sector players have been using blockchain technologies in various areas such as digital economy, voting platforms, oil and gas industry, fueling processes, banking, not to mention airline ticket sales and even control of diamond's production and supply chain among many others. Moreover, the investigation of the potential of blockchain is also strongly financed by establishing blockchain laboratories and providing a favorable environment for creation and development of startups.

The next sections observe the public sector initiatives which present the use cases of blockchain mechanisms implemented on the administrative level as well as the plans of the Russian government in this area for the next years. Additionally, an overview of blockchain initiatives in the industry and financial sector is given where the key elements and activities are showcased.

Public Sector Initiatives

Legislation

Keen to stay at the forefront of developing a clear and concise legal framework for a digital economy, the president of Russia, Vladimir Putin, set a firm deadline for the country to begin taking on regulations on cryptocurrencies, starting July 1st (Partz, 2019). Russia's parliament, the State Duma, is working on that and in March 2019 voted to pass digital rights legislation that will come into force in October 2019. According to the reports, the law establishes the concept of "digital rights" in Russian legislation and defines how they can be exercised and transferred, as well as sets rules for digital transactions and contracts. According to the Chairman of the State Duma, Vyacheslav Volodin, digital rights law "forms the basis for the development of the digital economy". This decision follows a long debate on how to treat digital currencies with legislative proceedings in the form of a draft bill on cryptocurrency with the title "On Digital Financial Assets" (Suberg, 2019). The Duma passed the crypto bill during the second of three readings in March 2019 (Yakubowski, 2019).

Administration / e-Government

Russia, in particular Moscow is extending its use of blockchain-based technologies taking in to the Ethereum-based voting platform at the city block level. Launched in 2014, Active Citizen is an electronic voting platform that runs on a private version of Ethereum and by March 2018 it had more than two million users. In that time, it has facilitated 3,510 polls where users voted on various subjects like the name for a new metro train and the color of seats in a new sports arena (Hochstein, 2018). Active Citizen began using blockchain technology to make results publicly auditable and alleviate concerns about the city's vote counting (Castillo, 2018)

In October 2017, the Ministry of Economic Development of the Russian Federation announced a pilot program developed to test the realization and reliability of using a blockchain for land registry in order to track the real estate information. The testing period was scheduled to run from January 1 to July 1 with the results being submitted by September 1, 2018. According to the initiators, blockchain technology "will be aimed at increasing the availability of information on the property registry, guarantees of protection of property rights, as well as the level of citizens' trust in the sphere of turnover of real estate." (Nation, 2017) According to the latest reports, the process of migrating to the platform that uses blockchain technology based on Ethereum has been extended due to the problems that appeared because of the volume of data that needs to be transferred (Tadviser, 2019).

Startups, Companies and Private Sector Initiatives

Two largest Russian banks are piloting cryptocurrency portfolios for their private clients: Sberbank and Alfa-Bank will offer their clients shares in a special fund that will be trading the six most popular cryptocurrencies on major exchanges, including Kraken and Bitstamp (Baydakova, 2018).

In May 2018, Russia's largest state-funded retail bank, Sberbank, together with Russia's National Settlement Depository (NSD), announced that they were working on a test ICO. At the time, Sberbank senior vice president Igor Bulantsev said in a statement that "many Sberbank clients are interested in this type of investment, and we plan to promote this service proactively once the appropriate legislative framework comes into effect; we will be one of the drivers to institutionalize and popularize this type of transaction." (Baydakova, 2018)

In September 2018, the Bank of Russia successfully conducted an experiment on token issuance – it was an experimental ICO based on the existing infrastructure in the Bank of Russia's sandbox. According to (Baydakova, 2018), the experiment was a success but there were a lot of issues from a legal point of view, which were not explained.

Moreover, a Russian subsidiary of Raiffeisen Bank International started issuing electronic mortgages using local blockchain platform Masterchain, with the first procedure being carried out in September 2018. This way, Raiffeisen's e-mortgage is reportedly the first in the Russian market (Berman, 2018). According to the announcement, the e-mortgage document contains data on the parties of the transaction, the loan sum, the duration of the

credit, and the property purchased was published in the decentralized depository system (DDS) that is based on Masterchain (Maria Sarychova, 2018). Masterchain is a Russian network for transferring valuable data via blockchain developed by a group of major local banks under the lead of the Central Bank of Russia. According to Andrey Popov, head of the IT department of Raiffeisen Russia, the process runs as follows: the document verified by an e-signature is sent to the Russian state agency that collects data on real estate, Rosreestr, and is eventually checked there. After that, a “mortgage token” is sent back to Raiffeisen Bank to be placed at a file storage. The second step in applying blockchain to real estate would be to use it for contracts of sale and other real estate transactions (Berman, 2018).

The use of blockchain in Russia can also be found in the commercial aviation sector. In summer 2018, Gazprom’s (state-owned gas company) aviation refueling subsidiary Gazprom-Aero together with S7 Airlines (one of the biggest airline companies in Russia) and Alfa-Bank, Russia’s largest private bank, “developed and implemented blockchain-based joint smart-contracts (aviation fuel smart contracts — AFSC), improving speed and efficiency in reciprocal settlements in aviation refueling, as well as automating planning and accounting in fuel supplies” (Gazprom Neft, 2018). This is an automated trading operation between three parties: a bank, an airline and a fuel supplier. According to S7, “the application shares data about fuel demand on a shared ledger, a copy of which is managed by each of the three parties” (Zhao, 2018). After that, payments for the fuel can be carried out on the network, with digital invoices created via smart contract during each transaction. The aim of the implementation was to speed up the transaction processes what, according to S7, was successful and took only 60 seconds eliminating a number of manual operations (S7 Airlines, 2018).

Apart from that, S7 is using Ethereum-based blockchain to issue passenger tickets with support from the country’s largest private bank Alfa-Bank. According to reports, the platform is designed to reduce settlement times between the airline and the agent by providing the payment with a deducted commission automatically after the ticket sales, which today takes approximately two weeks (Kommersant, 2017).

According to (Tracxn, n.d.), there are 263 blockchain startups in Russia that work in various sectors. For example, Bitcarat, a startup backed by the country’s education and science ministry has come up with a blockchain-based technology for tracing diamond’s production and supply chain and according to news reports, it is also planning a diamond-backed stablecoin.

Other Initiatives

Apart from only using the existing blockchain mechanisms, there are some initiatives that are taken to develop new technologies. For example, Sberbank, one of the largest banks in Russia, announced creation of a blockchain laboratory to develop and test blockchain-based solutions. The lab will aim at generating the product prototypes, perform pilot tests and deploy blockchain-based business solutions for Sberbank Group and general application of blockchain in the banking sector (Sundararajan, 2018).

Moreover, the officials plan to develop a road map for blockchain development in Russia by June 2019 and invest 10 to 15 million rubles in each blockchain project. According to reports, in total over 4 billion rubles will be spent on supporting development based on early-stage straight-through technology this year. At the moment they are working on a selection procedure for major research centers (Invest Foresight, 2019).

Industry Focus

Russia can be seen applying blockchain technologies in various fields by the biggest players in the industry sector. The leading industry in the Russian Federation that are actively adopting the blockchain-based technology is oil and gas industry, which is the key industry of the country. For instance, largest Russian state-owned gas company Gazprom is planning to use blockchain to execute and monitor business contracts. According to the firm's CEO, Alexey Miller, Gazprom is "ready to start the process" of digitizing the gas supply process using distributed ledger technology in its operations (Miller, 2019). Miller explained that together with the state-owned Gazprombank (Russia's third largest bank and Gazprom's subsidiary) they have developed a prototype of a technological platform to automate the process of concluding, monitoring and executing contracts. This system also provides for automated arbitrage and calculation of payments for gas" (Miller, 2019).

Another Gazprom's subsidiary, Gazprom Neft, the third largest oil producer in Russia, began testing blockchain in order to improve logistics and procurement management in February 2018. Moreover, two months later Gazprombank announced it was considering allowing its wealthy clients to trade cryptocurrencies – nevertheless, no concrete details were given at that time (Khatri, 2019).

Conclusion

Considering all the activities regarding the application of the blockchain mechanisms in public and private sector, including research and development startups, Russia can be seen accepting the blockchain mechanisms and relying on its potential. The government of Russia strongly supports digitization and passes on laws and regulations in its favor, in particular blockchain. Being a country that relies heavily on its oil and gas industry, the biggest players in this sector are actively adopting blockchain for various purposes starting from executing contracts of payments to monitoring logistics. Aside of that, the financial sector is also engaging blockchain into its core mechanisms: for instance, a Russian subsidiary of Raiffeisen Bank International started issuing electronic mortgages using local blockchain platform Masterchain, and two of the biggest Russian banks will offer their clients shares in a special fund that will be trading the six most popular cryptocurrencies. Furthermore, the public sector is also constantly developing various use cases for blockchain-based technologies on different administrative levels and is successfully carrying out pilot testing.

Singapore

Singapore is an island and city state, the smallest in Southeast Asia by area and one of the richest countries in the world. Together with Hong Kong it is Asia's most important financial center. According to the Index of Economic Freedom its economy is the second freest in the world, right after Hong Kong and before New Zealand and Switzerland (Heritage Foundation, 2019). In the Global Competitiveness Index of the World Economic Forum, Singapore is ranked second – right after the United States and before Switzerland and Germany (World Economic Forum, 2018), particular strong regarding the infrastructure, institutions, financial system, and product as well as labor market and ICT (information and communication technology) adoption. In Singapore, according to a study by the "Lucerne University of Applied Sciences and Arts", the framework conditions for the FinTech-sector are the best in the world. The country clearly leads the ranking (Lucerne University of Applied Sciences and Arts, 2019). Against this background, it is not surprising that the country is also very open to blockchain technology.

Public Sector Initiatives

One reason for Singapore being among the leading centers for blockchain is the active role of the government. The government of Singapore has been very early in starting respective policies. Starting already in 2016, the Monetary Authority of Singapore (MAS) has been working in a partnership with R3, an enterprise blockchain software firm, and a consortium of financial institutions on Project Ubin. It is a proof-of-concept for central bank digital money to conduct inter-bank payments using blockchain technology. In next iterations in 2018, Delivery versus Payment (DvP), together with the Singapore Exchange, and Cross-border Payment versus Payment (PvP), together with the Bank of Canada (BoC) and the Bank of England (BoE) were evaluated (Monetary Authority of Singapore, 2019).

A reason why Singapore attracts many blockchain entrepreneurs may be found in are generally very low regulations and taxes, in particular there are no taxes on capital gains, and money can flow freely. At the same time the country is very safe and property is protected. Undoubtedly this helped blockchain projects to receive funding and assisted in making the country to becoming an important location for blockchain projects and crypto entrepreneurs that gained a lot of value during the boom of 2016/2017.

Direct Investment

The government of Singapore is even investing directly in blockchain projects. In November 2018 it became public that state investment firm Temasek Holdings invested in enterprise blockchain software firm R3 (Koh, 2018).

Legislation

The country also tries to establish a legal framework and communicate this proactively to secure its important role in the cryptofinance sector. The regulation is transparent and

encouraging towards the adoption of the technology, in contrast to other regulatory authorities around the world that are very hesitant. Representatives of the Monetary Authority of Singapore (MAS) speak at blockchain conferences, such as Ravi Menon, Managing Director in October 2017 at the Global Blockchain Business Conference. There he expressed his view that: “The key breakthrough of blockchain technology is its ability to establish trust in a decentralized system” (Menon, 2017). In November 2017 the MAS has released a Guide to Digital Token Offerings. It provides general guidance on the application of the securities laws in relation to offers or issues of digital tokens in Singapore and defines and categorizes such tokens (utility, payment and security tokens) (Monetary Authority of Singapore, 2017). In November 2018, the MAS has submitted a new Payment Services Bill (PSB) to the parliament that has already been in the consultation process since August 2016. It creates a regulatory regime for payment providers to bring certain cryptocurrencies under its jurisdiction and will affect digital wallets and digital tokens such as BTC and ETH (Wei, 2018).

Public administration and e-Government

The Singapore Public Service division has announced that it might adopt blockchain to verify vendors’ track records in its e-procurement portal where suppliers can conduct e-commerce with the Singapore Government. Moreover, the Singapore Customs Authority has launched a national trade platform using blockchain technology. The new system is used for declaring permits and other services for trade and logistics. Other sub branches of the Government have invested in blockchain projects for tracking and tracing materials and products in the food industry and building a platform for the medical industry (Lago, 2018).

Research

National University of Singapore was ranked the best non-American University for blockchain or cryptocurrency studies, the third best in the world and the only Asian university in the top 23 of the ranking (CEO World, 2018).

Together a number of institutes of higher education in Singapore, GovTech, the Government Technology Agency of Singapore has developed OpenCerts. It is a Proof of Concept for the use case of educational credentials. The objective was to create digital educational transcripts and certificates, based on open-standards, tamper-proof and usable across borders (GovTech, 2018).

Startups, Companies and Private Sector Initiatives

Due to the openness of its economy, especially its financial market and being already strong in ICT and Fintech, Singapore was a center for the world-wide boom of Initial Coin Offerings (ICOs) in 2018. Until the end of 2018 there were 634 blockchain or Cryptocurrency-related companies incorporated in Singapore. This number is based on an analysis of the public corporate register regarding the on companies’ name. The combined market value of these companies at that time was at \$8.3 billion (Yang, 2019).

How important Singapore is a major center for blockchain economy is also highlighted by the number of big blockchain Startups that are based there. In early April 2019, three blockchain Projects based in Singapore can be counted as Unicorns, as they each achieve a market capitalization of over \$1 billion: Litecoin (5.4 billion), Binance (2.6 billion) and Tron (2.0 billion) (CoinMarketCap, 2019).

- *Litecoin*: A cryptocurrency that is technically quite similar to Bitcoin. Its open source client has already been published in 2011, so in blockchain terms it is a veteran. Its main differences to Bitcoin are the faster transaction confirmations and a different hashing algorithm that is aimed at avoiding centralized miners. Litecoin is registered as a non-profit foundation in Singapore.
- *Binance*: The cryptocurrency exchange Binance is considered the world's biggest in terms of trading volume. Its platform can be used to trade more than 100 cryptocurrencies. However, Binance does not have an official location and offices around the world. It is opening offices in Singapore and establishes a Singapore dollar to cryptocurrency exchange in the country.
- *Tron*: Tron envisions to build a truly decentralized internet infrastructure through a decentralized content protocol. The ecosystem is supposed to enable direct interactions between the provider of digital content and the normal user. The Tron foundation is registered as non-profit organization in Singapore.

But also major traditional companies in Singapore are implementing blockchain-based solutions. An example is the Singapore's national Airline. After a proof of concept in February 2018, Singapore Airlines (supported by Microsoft and KPMG) launched the first airline loyalty program digital wallet based on blockchain technology in July 2018. Through the wallet, flight miles are converted to digital tokens that can be used for purchases in partner shops (Singapore Airlines, 2018).

Other Initiatives

The government of Singapore is in a public private partnership actively encouraging the blockchain scene through a government supported blockchain accelerator, run by venture capital firm Trive Ventures. Launched at the end of 2018, the "Tribe Accelerator" is aiming to build a neutral platform connecting key stakeholders to drive adoption of blockchain technology. In 2019 it focuses on Fintech and InsurTech, mobility and supply chain, data and telecommunication and energy and sustainability. Besides government agency Enterprise Singapore, BMW, Intel and BMW and others act as corporate partners of the program.

Industry Focus

The industry focus in Singapore lies on:

- Finance and Insurance Industry:
Fin Tech, Cryptocurrencies
- Information and Communication Technology:
blockchain technology fundamentals as the country is home to many major projects developing of basic blockchain technologies such as Litecoin, Tron and NEM
- Trade:
Trade Facilitation Platforms, Cross-border Payment

Conclusion

The small country of Singapore is a major center for the blockchain and Cryptocurrency ecosystem. Building on its solid basis in Finance and Fintech, open economy and financial markets with little regulation and low taxes it has embraced the new technology in a very proactive fashion. As a “Switzerland” in Asia it attracts crypto capital and foundations of big cryptocurrency projects. While other governments and regulators are still hesitant to touch the topic, the country’s central bank has already in 2017 openly communicated that it deems the technology as promising and issued guidelines for crypto tokens. Moreover, the government and administration from early on has also shown that it also evaluates the technology as a building block in its initiatives for digitalization.

Switzerland

Switzerland has traditionally been home to one of the world's leading financial centers with headquarters for leading companies in the financial sector. From early on the country has recognized that the digitalization might disrupt this industry that in 2017 accounted for 9.2 percent of the country’s GDP and 11.5 percent of the fiscal revenue of the country (Polynomics, 2018). To avoid the bitter experience the country made in the quartz crisis of its watchmaking industry in the 1970s and 1980s, it is actively promoting the digitalization of its financial industry. So far this transition seems to have been quite successful. According to a study by the “Lucerne University of Applied Sciences and Arts”, the framework conditions for the FinTech sector are very good in Switzerland. In the global Fintech hub ranking, the cities of Zurich and Geneva rank second and second respectively, after the leader Singapore, and London on fourth place. Copenhagen doesn’t appear in this ranking (Lucerne University of Applied Sciences and Arts, 2019).

As blockchain and cryptocurrencies in particular are seen as a potentially disrupting technologies for the financial sector, the country is following them closely and has started first initiatives in different sectors quite early. In January 2018, when this would have been unthinkable in many other countries, Johann Schneider-Ammann, Swiss economics minister, told journalists that the country wanted „to be the crypto-nation“ (Atkins, 2018).

Public Sector Initiatives

Due to the blockchain technology's expected relevance for the Swiss economy, the Swiss public sector has already been quite active in investigating the technology, its potential effects on the economy and administration as well as required adjustments regarding policy and legislation. In February 2018, FINMA (Swiss Financial Market Supervisory Authority), as the world's first financial market regulator, presented a guide on how to treat ICOs under financial market law. In December 2018, Infrachain '18 took place, the first blockchain-Conference for public administration and infrastructure service operators. It was organized by the Swiss Blockchain Federation (see below) and opened by the Swiss Finance minister, which highlights how important the topic is for the country and its administration.

In blockchain research, Swiss universities are among the leading institutions in Europe. In a 2018 ranking of world's best universities for blockchain or cryptocurrency studies, the Swiss Federal Institute of Technology Zurich came in 6th as the best European university and the second best university outside of the US (CEO World, 2018).

SBB – Switzerland's rail company and one of the biggest public sector companies – enables its customers since 2016 to buy Bitcoin at any of the more than 1000 ticket machines throughout the country and to pay for tickets with this cryptocurrency. Very early on SBB has thus created Europe's largest network of ATMs for bitcoin withdrawals.

Different federal levels of the Swiss government have started initiatives in various areas. Two seem to be particularly advanced and will therefore be highlighted in the following.

Legislation

On 7 December 2018, the Swiss Federal Council adopted a 170-page report on the legal framework for blockchain and distributed ledger technology (DLT) in the financial sector (Federal Council of the Swiss Confederation, 2018). Blockchain and related technologies are predicted to offer significant potential for innovation and efficiency gains both in the financial sector and in other sectors of the economy. In Switzerland, a pronounced ecosystem with innovative Fintech and blockchain companies has already developed in recent years, particularly in the financial sector. The Federal Council therefore wants to further improve the conditions so that Switzerland can make effective use of the opportunities offered by digitization.

In the view of the Federal Council, it is important to create the best possible framework conditions so that Switzerland can establish and develop itself as a leading, innovative and sustainable location for Fintech and blockchain companies. At the same time, the Federal Council attaches great importance to ensuring that the integrity and good reputation of Switzerland as a financial and business location continue to be guaranteed in this area as well. The report provides an outline of relevant framework conditions, clarifies the need for action and proposes concrete measures.

Principles of the Swiss Federal Council approach are:

- Bottom-up approach: The preferences of the market and society should decide which technologies will prevail, while the policy should ensure optimal, innovation-friendly framework conditions.
- Targeted adjustments to the proven framework: Switzerland should not question its proven and balanced legal framework in principle, but should make targeted adjustments quickly if necessary, where there are gaps or obstacles with regard to DLT/blockchain applications.
- Basically technology-neutral approach: Switzerland should continue to follow a principle-based and technology-neutral legislative and regulatory approach, but allow exceptions if necessary. The rules should be as competition-neutral as possible.
- Legal certainty, clear rules and combating abuse: Switzerland should position itself as an attractive location for blockchain companies through legal certainty, efficient regulation and a good reputation. Fraudulent or abusive behavior and the use of innovative technologies to circumvent regulation in the financial sector will not be tolerated.
- Openness and dialogue: Swiss authorities should position themselves openly towards new technologies and innovations such as blockchain and DLT and maintain a regular dialogue with the industry.

Based on these principles and its evaluation of market, technology and the current legal framework the Federal Council does not see the need for a special “blockchain Law”⁹. It has, however, requested that a draft be drawn up for punctual adjustments in particular areas:

- to increase legal certainty in the transfer of rights by means of digital registers in civil law,
- in insolvency law to further clarify the segregation of crypto-based assets in the event of bankruptcy and to examine the segregation of non-assessable data,
- to elaborate a new and flexible approval vessel for blockchain-based financial market infrastructures in financial market law,
- in banking law to reconcile the provisions of banking insolvency law with the adaptations in general insolvency law, and
- to anchor more explicitly in money laundering law today's practice of making decentralized trading platforms subject to the Money Laundering Act.

Public administration and e-Government

Switzerland's regional administrative units are able to take and implement decisions quickly due to the country's decentralized political system. This is one reason why they were so fast

⁹ This is in contrast to small neighbor Liechtenstein that is planning the „Gesetz über auf vertrauenswürdigen Technologien (VT) beruhende Transaktionssysteme“ (Law on Transaction Systems Based on Trusted Technologies (VT)) for 2019. It will regulate crypto currencies and initial coin offerings (ICOs), but also the "token economy" as a whole.

in adjusting their legislation and administration to attract the crypto economy. Another reason are certainly the foundation law and the very low income and wealth taxes (especially in the Kanton of Zug) that attracted many big crypto foundations with full pockets.

In 2016, Zug became the first city in the world to accept taxes in Bitcoin, and a year later the City of the “Crypto Valley Zug” (see also next section) announced the introduction of a decentralized digital identity framework based on blockchain. It was the first municipality in the world to offer all residents the opportunity to obtain a digital identity based on blockchain (Ethereum) technology, in particular uPort ID (Kohlhaas, 2017). Currently the citizens can use this eID for a bike-sharing service. The municipality is also considering its use of for electronic consultations, in 2018 a trial was held to evaluate to possibility of e-voting using a blockchain-based solution (Zug Municipality, 2019). Other federal entities followed. For example, in June 2018, the canton of Schaffhausen launched the so called “Schaffhauser eID+” that is “blockchain secured”.

Startups, Companies and Private Sector Initiatives

The 50 largest blockchain companies in Switzerland (and Liechtenstein) employ around 420 people. In total, around 3300 people work in the industry (excluding service providers), most of them in the Zug and Zurich area. More than half of the blockchain companies are based in the canton of Zug. But the Crypto Valley extends to many other cantons: 42 companies are now domiciled in Geneva and 39 in Ticino. Liechtenstein has 38 Crypto companies (CV VC AG, 2019).

Crypto Valley Zug

In 2014, Johann Gevers moved the blockchain transaction platform Monetas from Vancouver to Zug, laying the foundation for the Crypto Valley. He also coined this term. Shortly afterwards, Ethereum founder Vitalik Buterin moved to Zug, which probably helped the Valley to its breakthrough. In 2018, Zug in Switzerland has been ranged fastest-growing tech hub in Europe¹⁰ in a study on the state of the European tech sector (Atomico, 2018). Moreover, Zug comes in third in a ranking of the world’s top 10 “Blockchain Cities” (Cohen, 2018).

While the market valuation of the 50 largest blockchain companies in the Crypto Valley fell within three months in 2018 from 44 to 20 billion US dollars, the number of companies rose in the same period from 629 to 750 at the end of December 2018. On average, the top 50 companies are valued at 400 million US dollars each. If the top five are ignored, the figure is still 365 million dollars each. Four Unicorns - startups with a valuation of billions are located in the Crypto Valley (CV VC AG, 2019):

- *Ethereum*: Ethereum enables the creation, administration and execution of decentralized programs or contracts (Smart Contracts) through its blockchain. It uses

¹⁰ While this ranking is based on the figure „year-on-year growth of attendees to tech-related Meetup events“, this is still remarkable for a city that is otherwise not really known.

the internal cryptocurrency Ether as a means of payment for transaction processing, which is processed by participating computers. As of April 2019, Ether is the crypto currency with the second largest market capitalization after Bitcoin. The Ethereum Foundation (Stiftung Ethereum, non-profit), is registered in Zug.

- *Bitmain*: A blockchain and semiconductor company, focused on the design and manufacturing of high performance computing chips and software. The company provides blockchain securitization, AI machine learning and more. The company's Fintech hub including a decentralized exchange is located in Switzerland.
- *Dfinity*: A is a blockchain-based cloud computing project that to host business applications at scale. The Dfinity network is self-governing through the use of an adaptive network called the Blockchain Nervous System (BNS). It is also capable of achieving transaction finality at an average speed of 7.5 seconds due to advancements in random number generation and selection. It is registered as a non-profit foundation in Zug.
- *Cardano*: A decentralized public blockchain and cryptocurrency project developing a smart contract platform. The project was launched in 2015 and aims to redesign the way crypto currencies are developed at different levels and ultimately create a decentralized platform for complex, programmable transfers of values with high levels of scalability and security. The Cardano non-profit foundation is registered in Zug.

Other Initiatives

Swiss Blockchain Federation

The Swiss Blockchain Federation is a Public Private Partnership. It is committed to maintaining and expanding the attractiveness and competitiveness of Switzerland as a blockchain location. Its Board of directors contains representatives from blockchain and Digital Innovation Initiatives, Universities, as well as from federal state governments. As most important challenges it pursues the creation of legal certainty, favorable framework conditions and a broad-based ecosystem for blockchain technology in Switzerland. The Swiss Blockchain Federation illustrates how closely the public (including research) and private sector work together regarding blockchain in Switzerland.

Crypto Valley Association

An independent, government-supported association established to build the world's leading blockchain and cryptographic technologies ecosystem in Switzerland. It supports and connects startups and established enterprises, initiates and enables research, organizes conferences, hackathons, and other industry events. It's over 1000 members are from the public (including research) and private sector, such as the municipality of Zug, pwc, Bitcoin Suisse, Lucerne University of Applied Sciences and Arts, Thomson Reuters and others.

Industry Focus

The industry focus in Switzerland lies on:

- Finance and Insurance Industry:
Fin Tech, Cryptocurrencies
- Public administration:
electronic identities, regulation
- Information and Communication Technology:
Blockchain technology fundamentals as the country is home to many foundations of basic blockchain technologies such as Ethereum and Cardano

Conclusion

Switzerland can be seen as one of the leading countries when it comes to blockchain in the public as well as the private sectors. Coming from the background of the Financial and FinTech industry as well as its low regulative hurdles regarding financial markets and taxes, it has been an early point of attraction for blockchain projects. Now it is the home for many important foundations of blockchain Projects and Startups. The country has built on this and is further developing this position through public private sector initiatives as well as legislative developments.

United States of America

As one of the largest economic structures and markets on the planet and the only superpower, the United States of America (US) is of obvious interest to this analysis. With that, there is a strong US tradition for leading in innovation and actively incorporating and investing into the utilization of new technologies.

Public Sector Initiatives

Legislation

Eight federal states in the US (Arizona, California, Hawaii, Illinois, Maine, Nevada, North Dakota, Vermont) are working on laws for regulating use of blockchain. Currently at federal level there is no regulation, but a proposed non-binding Resolution 835, promoting economic growth nationally calling on Congress to create a national policy for specific technology, including digital currencies and blockchain (Parker, 2017) (Desouza, et al., 2018).

Delaware, the US state that has most public companies registered, is considering the use of blockchain solution, which will be faster and cheaper than the existing process automating a number of processes (including share registry, capital-table management and shareholder communications) (Vigna, 2016). More than one million companies are incorporated in Delaware, including half of all publicly traded companies in the U.S. and 65 percent of the Fortune 500. Incorporation services have been an important part of Delaware's economy, but the state seems to be losing its competitive advantages to other business-friendly jurisdictions in the U.S. and abroad, which are making efforts to attract new businesses. Delaware must now make special efforts to keep companies in the state and attract new ones, and a simplified and more efficient record-keeping system could certainly help (Prisco, 2016).

A 2018 US congress report (Committee on Science, Space, and Technology, 2018), outlines potential uses of blockchain in the US society emphasizing "China, Japan, the United Arab Emirates, and the European Union have all taken blockchain technology quite seriously. They have all invested in research and initiated pilot programs using the technology. The European Union has begun to examine some of the potential needs for blockchain regulation, while trying not to stifle innovation."

Administration / e-Government

The US Department of Homeland Security has a million dollars to Virginia startup DigitalBazaar (<https://digitalbazaar.com/>). DigitalBazaar is working on a wide variety of specially built blockchains to help increase identity verification capabilities. The grant was awarded as part of the further development of the Homeland Security Enterprise Initiative (Nation, 2017).

Like other authorities, US authorities (Department of Homeland Security, 2018) are looking for "solutions that enable law enforcement investigations to perform forensic analysis on blockchain transactions. This analysis can be approached in any number of ways and may consider different data situation use cases depending on whether additional data from off-chain sources are available".

Startups, Companies and Private Sector Initiatives

Even if a brain drain of US start-ups has been reported (Boring, 2016), the investment in blockchain projects is reported higher than in other (Deloitte US Survey 2018 (Deloitte, 2018) p. 18) although the specific plans for applying blockchain seems much lower than in the other countries analyzed (Deloitte US Survey 2018 (Deloitte, 2018) p. 31).

Industry Focus

As US companies are among global leaders in practically all industries, as to be expected there are blockchain based initiatives found in all sectors, banking and finance in general,

media, information and communication etc. (Deloitte, 2018). These very large companies of global reach often conduct their pilot projects together with other global partners as IBM mentoring blockchain activities within retail with WalMart, supply chain with Maersk and production with Bosch.

Further as being from the US, the big consulting companies (Accenture, DeLoitte, E&Y, McKinsey, PwC etc.) are of particular influence in affecting their customers, corporations and governments globally in their perception of new technologies. This is also the case for blockchain being quite heavily promoted by above in their push for new business areas to develop.

Conclusion

The US has traditionally been and will expectedly continue to be the global economical and industrial powerhouse. After a slightly reluctant start, the level of investment into blockchain projects is as high in the US than anywhere else, so effects will expectedly be seen in the coming years (Deloitte, 2018).

Also, for start-ups to succeed, there is no alternative than launching your venture on the US market (personal communication from several start-ups – not yet published) both to get market exposure and critical capital.

Learnings from the Comparative Analysis

A key learning here is the widespread level of activity in using blockchain, many of which are innovative offering services not previously available to society.

Another learning is that several governments strive towards become leaders in the blockchain game providing support, economical and legislative.

Lastly the global aspect of most blockchain-based services should be emphasized, providing ample opportunities both for corporations, population and vendors of these services.

Venezuela

Venezuela is the country with the largest proven oil reserves in the world. The country's economy is almost completely dependent on the export of oil. However, in the last years the country fell into a major political and economic crisis with supply shortages and famines. According to the Index of Economic Freedom its economy is the second most repressed in the world – only North Korea is ranked worse (Heritage Foundation, 2019). The Global Competitiveness Index ranks the country 127th of 140 (World Economic Forum,

2018). According to the International Monetary Fund (IMF) the predicted GDP change for 2019 is -25 percent. However, one even more striking problem of the country is its soaring hyperinflation. For 2019 the IMF predicts a change in consumer prices of 10 million percent, while in 2018 it had already been at 929 thousand percent and in 2017 at 493 percent (International Monetary Fund, 2019). Thus, Venezuela is interesting here due to its attempt to deploy blockchain solutions strategically.

Public Sector Initiatives

Faced with the hyperinflation, the government of Venezuela announced in December 2017 that it plans to launch a cryptocurrency that is backed by the country's oil and mineral reserves. It hopes that backing the currency by commodity on an open source platform would be able to restore trust and slow down the inflation.

In February/March 2018 the ICO of the Petro (PTR) or Petromoneda tokens started and a white paper was released in March of the same year. This was the first cryptocurrency officially launched by a government (Krygier, 2018). One petro is supposed to represent a barrel of crude oil from a specific division in the country's oil reserves. As the white paper states, the country will accept Petros as a form of payment of national taxes, fees, contributions and public services, taking as a reference the price of the barrel (Gobierno Bolivariano de Venezuela, 2018). Observer have, however, been very skeptical if the currency would actually be of any use, as the reason for the hyperinflation is seen in a lack of trust into the government and in spite of the petro being somehow blockchain-based, the government might still be able to manipulate the currency. Moreover, the oil industry of the country is facing huge problems due to mismanagement (Krygier, 2018).

By April 2019 however, the Petro is still not listed on sites reporting cryptocurrency exchange rates. Coinmarketcap.com for example lists list 2160 cryptocurrencies, but the Petro is missing. The official website of the Petro quotes the current price for 1 Petro to be around 53 EUR (interestingly it lists the price in EUR, RUB, CNY and USD, but not in the official Venezuelan currency: bolívar soberano) (Gobierno Bolivariano de Venezuela, 2019). The Twitter account of the petro quotes the Petro in bolívar soberano with 197,768.51 (Petro, 2019). The petro website states state through a "Petro App" it should be possible to acquire the currency against Bitcoin and Litecoin (Gobierno Bolivariano de Venezuela, 2019). It remains unclear if the currency is of some practical value and it is hard to obtain as it is not traded on established international cryptocurrency exchanges even though it has been repeatedly announced that this would be possible in the future.

In January 2019 reporters managed to get in contact with a crypto enthusiast in Venezuela that sent them some Petro tokens that arrived in their wallet and was visible in the official Petro blockchain explorer. Nevertheless, it was unclear what the tokens were worth as different Venezuelan entities reported us different exchange rates. Whether the Petro can be used to purchase anything or pay taxes remains unclear (Memoria, 2019). In April 2019 the Twitter account of Superintendencia Nacional de Criptoactivos (SUNACRIP), the body regulating cryptoasset related activities in the country, published photos that were

supposed to show Venezuelans acquiring certificates of their savings in Petro (SUNACRIP, 2019). Still, independent reports of its practical use could not be found at the time of writing.

To regulate and monitor blockchain and cryptocurrency-related activities as well as explore use cases and efficiency of the technology, Venezuela had established SUNACRIP as a new governmental entity in January 2019. Since then, crypto-mining, exchanges and trading need an official license issued by SUNACRIP. While it is unclear how this is supposed to be enforced in practice, the fines are apparently meant to deter: between \$3,000 and \$18,000 – payable in Petro (Torres, 2019).

Companies and Private Sector

Already in 2017, there have been reports that Bitcoin had emerged as the most important parallel currency in Venezuela used for private transactions and as a means to store value. As it is barely possible to get a hold of US-Dollars, and as no official bank account is needed, Bitcoin as a digital currency that is not under control of a central bank stepped in (Fuster, 2017).

Despite being highly volatile, cryptocurrencies like Bitcoin are still more stable in value compared to the Venezuelan Bolivar in a hyperinflation and are a protection against foreign exchange controls. Cryptocurrencies might also be used to avoid sanctions that prevent US companies in dealings with certain Venezuelan nationals (Vilner, 2018). In February 2019, bitcoin trading arrived at an all-time high in Venezuela, with a weekly trading volume of over 2000 BTC on one particular decentralized exchange. This is an over four-fold increase since summer 2018. Until early March, almost 63 Million US-Dollar had already been traded in 2019. Still, this single exchange is expected to represent just a fraction of overall estimated Bitcoin trading by Venezuelans, with the most volume taking place in neighboring countries (Janus, 2019). Following the blackout that affected the capital Caracas and many states in March 2019, the weekly transaction volume of Bitcoin in Venezuela dropped by 40 percent (Kim, 2019).

Since February 2019, the Venezuelan Government tries to limit the capital flight into cryptocurrencies by introducing new regulations that tax crypto transactions (with at least around 0.25 EUR or a maximum of 15 percent per transaction) and introducing a monthly cap of around 600 USD for all transactions (Diaz, 2019).

In March Bloomberg reported that the U.S. government is considering tightening the sanctions on Venezuela. This would result in prohibiting Visa, MasterCard and other financial institutions from processing transactions in Venezuela. This would of course intensify the economic crisis in the country and cut it off from the global economy (Talev, 2019). It also might drive more people towards Bitcoin and other cryptocurrencies.

Conclusion

Venezuela is certainly a very special example. The political difficulties and the closely related hyperinflation make it hard to compare the country with the others listed in this report. Based on the hyperinflation, the focus in the country is currently clearly on cryptocurrencies. Other applications of blockchain technology do not seem to be taken into consideration – there are simply more pressing issues.

Blockchain is currently used twofold in the country – with varying success:

The Venezuelan state tries to reestablish trust into its currency by proclaiming a new cryptocurrency. As this approach seems to fail it also illustrates that just introducing some kind of blockchain as such cannot solve deeper trust issues. The governance of the whole system within which the blockchain is being used is still important. And if this governance – in the case of Venezuela actually the government – is not trusted by the other actors, the blockchain as such cannot establish trust as the whole system is flawed.

On the other hand, the people of Venezuela and parts of the private sector use the blockchain pragmatically. Faced with soaring inflation and a shortage of stable means of payment and means to store value, they use a technology that is readily available for people with access to the internet and hard to control for governments. Apparently, this use case seems to actually work for them under the given circumstances.

E SCENARIO ANALYSIS

In the following chapter, we will investigate four plausible scenarios describing possible future outcomes of blockchain assimilation and use in Denmark. A scenario is different from a prognosis in that it attempts to consider possible developments and turning points, only some of which may be found today, that is, in the past of the scenarios. A prognosis describes a future as one believes it will likely turn out. To obtain insight into the future situations and the paths leading to the outcomes, four selected scenarios are outlined:

- **Aspirational Scenario:** Efficient public-private collaboration
- **Transformational Scenario:** Strong industrial lead
- **New Equilibrium Scenario:** Global competition and dominance
- **Collapse Scenario:** Distributed Ledger Technology for niche applications

While we used the term blockchain throughout the report, as it is the term commonly used, for the scenario analysis we assume that in the future the accurate term Distributed Ledger Technology (DLT) will be used. Thus, even though we used blockchain as synonym for DLT throughout the report, we believe it is consistent with the forward-looking nature of scenario analyses to also use the term that is most likely the more commonly used one in the future.

Methodological Reference

For the scenario analyses itself, we received guidance and inspiration by Jim Dator's work on alternative future (Dator 1979). We furthermore used the example of scenario analyses for Australia as orientation for our methodology (Hanson, et al., 2017) (Bezold, 2009).

Aspirational Scenario: Efficient public-private collaboration

The World of 2030

Denmark and the European Union have fully embraced DLT together with other emerging technologies in areas such as AI and IoT. In close collaboration with industry and end-user's legislation, regulation and standardization support and govern the use of these new and innovative technologies to the mutual benefit of industry and society is promoted. Careful implementation of DLT systems has enabled distributed, high assurance identity and trust management infrastructures that preserve the privacy of citizens and confidentiality of business transactions based on reliable, government vetted trust anchors. DLT enabled regulation technology automatically monitors compliance increasing transparency and oversight in virtually all relevant industry sectors while drastically reducing operating expenses through reduced losses from lack of transparency and expelling of redundant control systems. Thus, the RegTech industry thrives providing innovative governance, risk and compliance tools that not only supports audits and transparency but at the same time valuable data for AI applications and insights for the strategic business development.

The Danish government has not only supported the deployment of DLT for industry use but has adjusted its own administrative processes ranging from citizen services, taxation, and industry oversight to levy synergies from DLT use. This has also greatly benefited the Danish legal and accounting services sector.

While closely aligned with European financial regulation and the Danish financial industry, Denmark has used its independence from the Euro to establish a digital

Danish Krone as a programmable currency for micropayments which has significantly increased the competitive edge of Danish industry and digital services. At the same time, the use of a programmable currency has increased governance opportunities for ensuring that allocated public funds really are used for the specific purposes intended, reducing waste and fraud.

Charging stations for electric vehicles and drones are distributed across the territory with DLT-enabled fraud prevention and automated micropayments. A country-wide DLT energy supply and carbon emission trading system has been set up comprising the entire grid from smart meters, to wind turbines up to large power stations. Danish manufacturers of wind turbines successfully sell “plug and play” packages that enable the smooth integration of wind turbines into energy grids including DLT-based net metering, payment and financing services.



DLT-enabled integrated care systems connect Danish eHealth infrastructures using fine-grained, transparent, privacy friendly, and auditable DLT-based access control techniques. The eHealth services facilitate the management of co-morbidities in the elderly population integrating and orchestrating treatment plans across the healthcare continuum from hospital care, nursing homes, general practitioners, specialists, therapists, pharmacists, dieticians, family members and IoT enabled devices monitoring a patient’s status at home. The overall network improves information sharing for the benefit of the patients and drastically reducing complications in the treatment of comorbidities due to incompatible care plans significantly reducing costs in providing world-class health care.

The Danish shipping industry further gains in competitiveness as DLT has been developed into a full-fledged supply chain operating system. Bills of lading are processed fully electronically enabling automated customs clearance, VAT payments and processing, onwards transport logistics and highly automated just-in-time delivery increasing transparency, vital in supply chain management, and reducing working capital from increasing equipment turn-around.

The provenance and integrity of Danish pharmaceutical products can be verified via the combination of DLT with innovative methods to imprint codes directly on pills, the on-the-fly analysis of the surface and chemical structure of pharmaceuticals, IoT enabled temperature monitoring, and bar-coding from individual packages to large shipments. These measures ensure proper handling in transport and prevent counterfeiting and fraud along the entire supply chain.

The Danish livestock industry offers certified, DLT-based, bidirectional tracking and tracing for Danish meat products. End-customer can verify online the farm of origin and – especially for biological products - the sources of the fodder fed to the animals. Well-designed user interfaces give every partner along the meat supply chain full transparency regarding the movements and locations of meat items and guarantee accurate monitoring and documentation of process and event data.






Commentary

	Supply Chain Industry	Danish Labor Market
Opportunities 	A new level of cost efficiency, automated processing of former “paperwork” and transparency significantly increases global competitiveness.	New job opportunities along the entire value creation networks in sectors such as agriculture, health, energy, transport, finance legal and accounting.
Risks 	Insufficient speed of cross border integration and standardization at the EU and world-wide level reduces potential synergies.	Lack of qualified experts (policy, legal, user experience, DLT developers) to design, implement and operate large scale DLT infrastructures might limit growth potential.

Impact

Legal  ¹¹	<p>All stakeholders greatly benefit from clear regulatory and legal guidelines providing markets with a solid fundament for growth and industry wide standardization. Regulation technology significantly reduces compliance costs and increases transparency and processing speeds.</p> <p>Denmark is widely regarded as a flagship country demonstrating how responsible governance of new technologies such as DLT can and should be implemented. It is the jurisdiction of choice in the EU especially for the logistics, transportation and supply chain industry further strengthening Denmark’s excellent positioning in these sectors as well as services including finance, legal and accounting. This strong position assures innovative companies that Denmark is an excellent place for investing in other new technologies such IoT, and AI, thus contributing to current and future clusters.</p>
Innovation	DLT facilitates new and privacy friendly approaches for the management of sensitive personnel data in sectors like health as well as confidential data in industry. Through innovative use of DLT privacy protection goals like transparency, intervenability and accountability can be accomplished

¹¹ Icon made by Freepik from www.flaticon.com

	<p>in new and highly efficient manners giving citizens new means to control and monitor access to their personnel data even in B2B transactions. In combination with big data technologies, IoT and AI, DLT enables the aggregation of data from trusted sources for the protection and maintenance of critical infrastructures in sectors ranging from the ICT, financial services, healthcare, transportation and energy. Public-private-partnerships drive fruitful exchange of innovations in industry solutions and government services.</p>
<p>Quality</p> 	<p>Novel and wide spread DLT-based governance, risk, and compliance solutions boost the introduction of measurable and certified quality standards in most industry sectors. Personnel and confidential data are processed in a controlled, privacy friendly and transparent way. Organizational and technical measures to further measure and improve quality are closely interlinked.</p>
<p>User adoption</p> 	<p>Successful DLT user adoption in the logistics and supply chain sector combined with efficient DLT-based government services drive user adoption across industry sectors and society. Service providers successfully market DLT as a trustmark for reliability, transparency and efficiency to users in industry and society.</p>
<p>Integration</p> 	<p>Industry and government manage to closely integrate services not only within Denmark but also cross-border which proves important for key Danish industries in particular supply chain, transportation and logistics. The ability to reliably trace the origin of agricultural and pharmaceutical products across borders back to Denmark and the individual producer as well as the process before the consumer buys the product (Provenance) significantly supports the branding of Danish products globally.</p>
<p>Digital Currency</p> 	<p>Denmark is taking advantage of being a country with its own currency in the EU by quickly introducing and experimenting with digital currencies closely integrated with DLT-based platforms, e.g., for micropayments. This gives Denmark's supply chain, energy and financial services industry a significant competitive advantage in Europe driving innovation and novel business models. In close collaboration with the EU, Denmark tests the collection of customs revenues and taxation based on digital currencies thus leading the way for the Euro countries towards adopting digital currencies based on best practices developed in Denmark.</p>

Transformational Scenario: Strong Industrial Lead

The World of 2030

In this scenario the Danish government and the EU have been slow in driving legislation and regulation for DLT. EU member states, the European parliament and the European commission debated for a long-time what rights and responsibilities lie at the national and the EU level. The European central bank was reluctant to experiment with use cases for digital currencies and the Danish National Bank - though considering issuing central bank digital currencies - remained uncertain on how this will impact compliance with EU financial regulation and policies and thus delayed action.

Other countries, however, especially China, Russia and the OPEC states quickly built up large scale DLT infrastructures (with the associated patents (IP)) and issued partially asset backed (petroleum, gas) digital currencies.

In the meantime, industry made giant leaps forward in terms of global, open source DLT infrastructure development and standardization. Globally deployed DLT-backed supply chain operating systems are used in the shipping industry and levy significant synergies and cost savings. Port authorities connect to these systems as well, while customs and tax declaration are still processed by traditional means. However, EU government actors are under an increasing pressure to align their administrative processes with these infrastructures so that their countries (e.g., ports) remain globally competitive.



Large industrial DLT platforms for IoT integration especially in areas such as smart homes, smart cities, eHealth, and industrial IoT have been built at a global scale. Certain platforms and associated standards are dominated by global, non-EU players, and sometimes political influence in the background is perceived as strong. The introduction of programmable money and self-billing to closely integrate automated micropayments with microtransactions have enabled new, innovative service models for trillions of microtransactions per hour. Novel, industry driven mechanisms for out-of-court dispute resolution, capable to address issues in micro transaction processing challenge traditional dispute resolution mechanisms. Since the digital currencies used in these systems are industry controlled and issued, traditional governance models must be reviewed. In this context industry faces some regulatory and legal uncertainties regarding adequate accounting, but also regarding taxation and accountability about national governments. However, the overall system appears to be stable and reliable.

In many industries smart, DLT-based, programmable service level agreements (SLAs) automatically monitor and document performance of individual actors in large scale value creation networks. Integrated micropayments allow service consumers to place targeted incentives to service providers to encourage top performance when required. Fines for performances below the agreed SLA terms are applied automatically and transparently. These innovations lead to significant increases in productivity in the transportation and logistics sectors.



The research and educational sector has embraced DLT technology both for the EU-wide, largely automated management and recognition of ECTS credits, digital students IDs, as well as of university degrees facilitating a significantly increased mobility of students and young professionals. Employers appreciate the increased transparency regarding educational credentials including certified language skills across borders.





As the world's fifth largest shipping operator the Danish shipping, transportation and logistics sector has maintained a competitive position in the industry and has taken advantage of the high density of researchers and research organizations in Denmark. Thus, Denmark was able to keep a strong 7th place in world-wide patent applications as well as R&D spending (in percentage of GDP) also due to a strong performance of the pharmaceutical and biotechnology sectors.

Commentary

	Supply Chain Industry	Danish Labor Market
Opportunities 	<p>Significant cost savings and efficiency gains through global DLT-based platforms for supply chain management and logistics.</p>	<p>Novel DLT-based business models create new job opportunities in many important Danish industry and services sectors. Denmark profits from an increased transparency of academic transcripts and student mobility and can attract talent from many EU countries.</p>
Risks 	<p>Lack of integration with government services in Denmark reduces cost saving compared to other non-EU countries that have already reached these synergies. This might reduce the competitive edge of some Danish industry solutions.</p>	<p>Difficulty for Danish government to hire experts and train a sufficient number of employees for integrating DLT services in government managed platforms and for the adjustment of administrative processes as the need for these changes increases dramatically.</p>

Impact

Legal 	<p>In the absence of clear regulatory decisions by the Danish government and the EU, the decisive and consistent lead of industry in defining standards and rules of conduct creates an essential basis for the rapid development of DLT across industry sectors. Since industry managed to set-up, clear channels and transparent mechanisms for dispute resolution DLT sees rapid take-up. Some of these developments start to challenge traditional mechanisms for contracting and dispute resolution and thus government feels pressured to finally act and create a strong legal basis for now established industry practices.</p>
Innovation 	<p>DLT stimulates the industry-wide development of standards for secure DLT system architectures, as well as novel and distributed access control and data protection mechanisms. The transparent and privacy conserving aggregation of data from trusted sources for big data and AI-based applications yields new and significant insights. Standardized mechanisms to trace and confirm the provenance of agricultural and pharmaceutical products boost consumer confidence and supply chain efficiency. Industry</p>

	and universities collaborate intensively on research and development strengthening Denmark’s global position regarding patents, IP and product innovations.
<p>Quality</p> 	Digital academic transcripts and degree certificates improve transparency and mobility in the educational sector at the University level. Professional degree programs supported by industry follow suit. Continuous education and life-long learning credentials can be easily tracked and verified. DLT-based SLAs ensure tight quality control and targeted incentives for the provision of high to exceptional service quality in value creation networks.
<p>User adoption</p> 	Industry paid early attention to user needs, willingness to pay and socio-economic drivers of adoption. Not only the high-tech back-ends of DLT-based platforms have been carefully engineered, but the user experience and user behavior has been a focus of attention in the design of DLT solutions and user interfaces by industry across sectors. Users appreciate the combination of trusted data sourced from DLT infrastructures in combination with easy-to-use tools for big data analytics and AI.
<p>Integration</p> 	Industry lead initiatives drive the transparent integration and standardization of DLT in and across industries. Closer integration with government services is still outstanding but highly desirable. This integration will likely be driven by the adoption of industry standards by government.
<p>Digital Currency</p> 	Industry issued digital currencies in DLT-based platform have become an integral part for doing business and handling micropayments. As the importance and value of digital currencies in these systems increase, industry has the need to develop advanced financial products based on these currencies to hedge risks (but which can also be used for speculation in digital currency trading and exchange platforms). As significant investments are made and turnovers reach billions, important regulatory questions cannot be ignored posing new challenges for government regulators since these digital currencies are an integral part of industrial platforms spanning jurisdictions across the globe. Regulation must be applied carefully has regulators do not want to impede the competitive advantage of Danish industry players.

New Equilibrium Scenario: Global Competition and Dominance

The World of 2030


In this future user confidence in DLT could not be maintained by industry in Denmark and the EU. A few but widely noted initial scandals where citizens were lured into investing in digital currencies and DLT-based money market products and subsequently lost most of their investments, alerted both consumers and governments. Frivolous data handling in hastily created DLT-based consumer reward programs and social networks further eroded user confidence in DLT.


A famous example was the melt-down of a DLT-based social network used by high-school and University students to “help” each other with school assignments ranging from homework essays to PhD theses against payments in a network issued digital currency. A data breach revealed the identities of thousands of students and the “services” they had bought, with detrimental impact on their high-school and University careers. Furthermore, the digital currency used essentially lost its value within a single working day.

These developments led to a regulatory environment focused on containing risks and preventing further damages to citizens. This regulatory environment and slow user take-up make it difficult and expensive for industry to efficiently roll-out DLT-based platforms. Industry therefore focused on non-DLT-based solutions that are able to mimic DLT-based systems and provide similar services integrated into a reliable legal and regulatory framework increasing confidence in sound consumer protection and dispute resolution mechanisms.





However, these systems must now compete globally with DLT-based infrastructures supported by Russia and China and underpinning global projects like the Chinese \$900 billion New Silk Road. These developments threaten the competitive advantage of the Danish supply chain, logistics and transportation industry as the solutions based on traditional technology have difficulties to compete at this scale. Danish ports lose business to ports in southern Europe adhering to the Silk Road Project.



Commentary

	Supply Chain Industry	Danish Labor Market
Opportunities 	As DLT technology is increasingly avoided by industry there is innovation in improving legacy technology, which creates some business opportunities.	As investments in improving legacy technology surge the labor market remains strong and attracts innovators. The race for dominance

		between DLT and legacy technology has not yet been decided.
<p>Risks</p> 	<p>Legacy technology cannot compete with the large-scale roll-out of DLT in some large non-EU countries, putting the Danish supply chain industry under severe competitive pressure.</p>	<p>If Danish industry lost business to other (even EU) countries who are integrating closely with DLT-based platforms underpinning projects like the Silk Road, the Danish Labor market could be negatively affected from skilled to unskilled workers as DLT skilled workers would travel to countries with opportunities.</p>

Impact

<p>Legal</p> 	<p>Industry suffers from a lack of certainty regarding the use of DLT-based solutions and reverts to conventional technology able to reproduce some features of DLT whenever possible to work on a sound legal basis. Overall market confidence in DLT is negatively impacted and regulation is not supportive. For the supply chain industry this leads to a loss of efficiency and competitiveness compared other countries.</p>
<p>Innovation</p> 	<p>Industry invests heavily in the improvement of legacy technology in order to compete with DLT, thus trying to avoid legal and regulatory pitfalls. This leads to noticeable improvements, however the extent to which these updated legacy solutions are scalable and can be globally competitive is unclear. Innovations in DLT have taken place elsewhere. The final word on how this situation affects competitiveness in the long term is still outstanding.</p>
<p>Quality</p> 	<p>The absence of widely used standards and regulation makes it difficult for users and experts to easily evaluate the quality of DLT-based platforms and services. Thus, huge variations in the quality of DLT-based solutions and services characterize the market.</p>
<p>User adoption</p> 	<p>The difficulty to distinguish trustworthy from phony solutions and negative media coverage scare users away from DLT-based services and platforms. Large companies are reluctant to extend their brands to DLT-based solutions (e.g., by integrating technology developed by start-ups) as</p>

	they fear reputational damage. Users are thus looking for alternative solutions whenever possible.
<p>Integration</p> 	A lack of standardization and the absence of a consistent approach to DLT across industry sectors hampers integration of DLT within and across industries. Industry struggles to agree on security architectures and coherent risk assessment methodologies covering the entire value chain of DLT-based services.
<p>Digital Currency</p> 	There are plenty of digital currencies on the market, but few are of any significant value for industry. The currencies who are used by industry have been tied to fiat digital currencies by regulators thus creating de-facto silo use cases often restricted to certain jurisdictions.

Collapse Scenario: DLT for niche applications

The World of 2030

Government has been hostile towards adopting and regulating DLT. Significant uncertainties regarding the legal value of DLT-based records and organizational structures have undermined most foreseen synergies in industry networks. Government mandated compliance monitoring, and taxation has remained mostly off-chain thus further limiting opportunities to reduce operational expenses compared to traditional record processing in cloud-based applications.

The wide-spread, but hastily and un-coordinated implementation of DLT solutions by industry has led to major data leaks, and system wide security vulnerabilities. Hackers have taken advantage and were able to initiate fraudulent transactions thus severely undermining user trust in industry developed DLT solutions.

Thousands of different, industry-issued digital currencies for micropayments have remained highly volatile, thus making conversion rates into traditional currencies like the Danish crown unpredictable.

Distributed identity management systems where anyone can issue credentials to anyone regarding anything without reliable trust anchors have made most certifications, e.g., for university degrees via DLT systems practically worthless. Citizens revert again to scans of paperwork and manual verification in case of doubt. On the other hand, anonymous identities enabled by DLT have facilitated whistleblowing and allowed dissidents to network while still being required to take high precautions.



Furthermore, thought-through and reliable revocation mechanisms for DLT-based identity and trust management applications have not be properly implemented from the outset,

thus causing citizens significant monetary and reputational harm as they were tricked – via large scale social engineering attacks – into disclosing their private keys to fraudsters.


A major data leak in an eHealth application where personnel data was stored on-chain revealed the HIV status of hundreds of Danish citizens. As further personal data was linked to these medical records the de-pseudonymization of their identities was facilitated which caused these users permanent harm as well as a public outcry.






Overall DLT has achieved wide-spread traction only in online gaming and gambling. In industry, a few highly secured B2B applications are successfully operated in the financial and insurance sectors. Otherwise DLT is used in the darknet underpinning organized crime, illegal drugs and arms trading, elaborate money laundering and tax evasion schemes and other illicit activities.

Commentary

	Supply Chain Industry	Danish Labor Market
Opportunities 	As DLT has not kept up to its promises the industry is now focusing on IoT driven Big Data applications powering AI-based services leading to novel, non DLT-based innovations.	No opportunities related to DLT arise.
Risks 	As DLT platforms implemented by the supply chain industry have been affected by security breaches and data leaks, customer confidence in the industry has taken a significant hit, affecting revenues noticeably.	As trust in many DLT driven platforms has eroded customers are reluctant to do business with affected companies and industries. Negatively affecting revenues and job opportunities.

Impact

Legal 	DLT has received very bad publicity from which it never recovered. Regulation is focused on preventing further scandals and thus is DLT hostile. Since no reliable dispute resolution mechanisms exist, DLT cannot scale and achieve its potential efficiency gains. DLT has thus become an increasingly unattractive technology for the Danish industry.
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<p>Innovation</p> 	<p>DLT and digital currencies are most heavily used by organized crime for illegal online gambling, money laundering, tax evasion and other illicit activities. Otherwise there are only a few niche applications within some industry sectors but without a sizable impact on the Danish economy.</p>
<p>Quality</p> 	<p>Many hastily implemented and untrustworthy solutions are on the market and users have a hard time to distinguish the few reliable ones from the many phony products. Huge quality issues become apparent after several DLT-based services have attracted a large user basis. Such compromised DLT platforms are the source of data leaks that severely impact users' lives. Similar weaknesses affect some platforms operated by organized crime and have given investigators important leads to identify criminal users and to prosecute them.</p>
<p>User adoption</p> 	<p>Huge scandals and the use of many DLT platforms by organized crime have eliminated customer confidence and trust in this technology.</p>
<p>Integration</p> 	<p>Neither industry, government nor end-users are willing to put further trust and effort into DLT solutions. In some industries highly specialized niche products are in use. Thus, there are no incentives that could drive significant integration efforts.</p>
<p>Digital Currency</p> 	<p>Industry may do business essentially only in centrally issued fiat digital currencies. Only some of these currencies issued by non-EU economies see wide-spread use. There are plenty of black- and grey- market digital currencies available but these are not accessible to industry and tainted by illegal activities.</p>

These initial scenarios are quite self-explanatory. As per request we have looked specifically into the supply chain industry. The supply chain industry in Denmark has two faces that are over-lapping to a minor extent. One is the use of supply chain particularly, but not only among production companies. These are closely connected to Danish infrastructure, roads, airports, railways, transportation centers, terminals, ports etc.

The other consists of the transportation companies, both ocean transportation with several Danish players (such as DFDS, Torm, Norden) further to one enormous in container industry (Maersk) and in trucking (DSV now with Panalpina). All these companies have some traffic in and out of Denmark, but not the majority where the bulk of transactions are regional and/or global. That means internal Danish considerations apart from corporate laws are of

minor importance – but these companies are extremely sensitive to the many jurisdictions they operate under as well as to international agreements within trade, law in general, environment, as well as international standards and regulations for instance in IT-systems. Denmark expects to be the first country to deploy a blockchain-based shipping register.

Modern supply chain management is extremely systems intensive and for practical reasons these systems need to be able to receive and transfer data to and from other partners in the supply chain. Hence, cross-system standards are critical for a smooth and effective data-flow.

Supply chains in general are characterized by many partners. For example, for a simple port-to-port transport around 20 legal entities for logistic operations are needed (including paperwork, background services, door-to-door delivery, etc.). For practical reasons a high degree of transparency in a supply chain is needed so that the stakeholders are informed about the status of the shipments at any point in time. Due to these requirements, supply chains are obvious candidates for blockchain solutions to share data among legally independent, geographically distributed stakeholders which require a safe and secure sharing of data and systems.

As mentioned in the tables above, there are other key industries in Denmark where the application of blockchain-solutions appears to be promising, such as in the food-production and pharmaceutical industry, where trustworthy provenance is a key competitive and legislative element. Several blockchain initiatives are built around these as are related financial services as transactional insurance.

F CONCLUSION AND RECOMMENDATIONS

Conclusion

Cluster Analysis

Our analysis highlighted the economic relevance industry clusters and the remaining importance of location in a global economy. Further, a review was given of other cluster studies found in Denmark. In order to gain greater insights on the emerging Danish blockchain industry clusters, an additional Google trends analysis was conducted to illustrate the growing interest into blockchain and related topics in Denmark over time.

The Google trends analysis generated some key takeaways. The general public's interest in blockchain seems to be driven by the price for Bitcoin (or cryptocurrencies in general) to such a large extent that it overshadows other potential factors of influence. Such factors could have been news items about organizations starting blockchain projects or governments picking up the topic. Thus, the public perception is still very much driven by news articles and developments around cryptocurrencies, and not so much about the ample economic potentials in other areas. Our analysis shows that the few reports on blockchain beyond Bitcoin cannot outweigh the influence of the price of cryptocurrencies on the public interest on the topic.

The overview of the Danish blockchain cluster illustrated that most identified blockchain-related entities can be classified in three main sectors; Fintech, professional services industry and IT, and the maritime shipping and transportation industry. Those are the areas where most activities can be found in Denmark. The identified blockchain-related organizations were can be categorized within three groups; blockchain startups, blockchain hubs and network organization, and blockchain research centers, while the majority of activities is driven by a large blockchain startup scene in Denmark.

Danish Public and Private Sector Blockchain Initiatives

Regarding the current state of Danish public and private sector blockchain initiatives, the following concluding observations may slow down the development of a Danish blockchain industry cluster-

Unlike in the Netherlands or Switzerland there are no large-scale public sector initiatives in Denmark attempting to establish an eco-system for blockchain approaches.

The lack of major blockchain initiatives among the Danish banking industry stands in stark contrast to the lively and prosperous Fintech and blockchain start-up scenery in Denmark. The CPHFINTECH 'cluster' has gained an internationally recognized strong reputation for innovative solutions, but so far, those innovations have not made major inroads into the Danish banking and insurance industry.

At the same time, reports exist that Danish blockchain start-ups have a difficult time to get a bank account nor credit in Denmark which has forced them to go abroad. If this is a structural problem, it may create a disadvantage for the Danish startup and entrepreneur scene, as it forces blockchain startups to leave the country, or at least actively think about leaving the country. What would be needed is a concerted activity of the Danish banking industry as well as regulator to make sure that registered companies in Denmark also have access to the capital market.

Potential Impact and Future Development of Danish Supply Chain Industry Blockchain Cluster

Even though there is still a strong public focus on crypto currencies, stablecoins, and central bank digital currencies, it is worth noting that there is in the industry a strong interest in other application areas as well, such as in the supply chain industry. There, the initiatives typically focus on direct effects of blockchain solutions to reduce operational risks and ultimately costs through increased transparency and auditability.

There is little doubt that blockchain will be a significant shaping factor for future supply chains both from a user as well as service provider perspective. Current initiatives like Tradelens (Maersk/IBM) and Blockshipping build directly upon blockchain capabilities like transparency, authenticated event log records, immutable records, resilience in their solution architecture.

As supply chain is a substantial independent industry in Denmark with companies such as Maersk, DFDS, DSV, or Lauritzen, the impact on these is expectedly significant, both in terms of augmenting the services as of today as Tradelens is illustrating, but also in terms of launching completely new independent companies and services as illustrated by Blockshipping.

What is limiting a widespread assimilation of blockchain solutions so far is the lack of standardized open interfaces to existing legacy systems. This asks for solutions to guarantee interoperability for integrating systems that not just allow for the exchange of data, but actually solutions that allow to exchange business logics and reliability or approval processes across those systems, which goes beyond mere electronic data interchange.

Current Situation as Reported by the Companies in the Survey

The empirical survey brought forward many insights regarding the investigation and application of blockchain technology within the different investigated Danish industries.

An industry that has already invested a lot in proof of concepts around blockchain solutions is the finance and insurance industry. With the emergence of Bitcoin, it is this industry that was first confronted with the cryptocurrency and soon after the general applicability of blockchain for all kinds of financial purposes. While established market participants are hesitant to roll out blockchain-based production systems, blockchain, together with artificial intelligence, became the main driver of innovation for FinTech startups. However, other industries we investigated also showed a keen interest in exploring the potentials of blockchain for their purposes, such as the Danish information and communication industry.

From the data we were able to observe differences between companies that can be classified as “top performers”, “digital leaders”, and “strong innovators” in comparison to companies that do not fall into these groups, the “followers”. With that, at least 33 percent of top performers had some extent of knowledge in comparison to followers, where only 18 percent claimed to possess some knowledge on blockchain technology. As for strong

innovators, 40 percent claimed having at least some extent of knowledge and also reported that 40 percent having already some sort of engagement with blockchain technology.

Another impressive result that was found was that 15 percent of large companies and twelve percent of medium-sized companies use blockchain technology at least to some extent. This is a very positive result given the early stage that the different DLT and blockchain technologies are in. In addition, around 34 percent of companies expect to apply blockchain solutions in the future.

The largest share of companies that expects an influence of blockchain-based innovations anticipates it to affect their business strategies or models. This is supported by almost half (48 percent) of the companies stating to anticipating this at least to some extent. On the other hand, the share of companies that – at least in their opinion – would have to be afraid of blockchain as it might adversely affect the companies' business model is at a rather low 10 percent (at least to some extent).

A lack of standardized solutions and of experts is seen as the most important impediment for assimilation blockchain solutions at the moment. Given that blockchain is still a relatively new technology, this survey outcome is not surprising. Standardization activities and more training and education programs that educate blockchain experts seem to be required.

Challenges for a broader assimilation of DLT systems also arise from legal issues. However, what comes out somewhat as a surprise is that top performers, as well as strong innovators, and digital leaders regard legal challenges in applying blockchain solutions as a bigger issue than their respective follower-groups. One possible interpretation for this outcome is that the leading innovators and performers have investigated and explored the potentials of blockchain already and thus are fully aware of the complexity. Alternatively, the respective followers might bet upon the fact that once they are assimilating blockchain solutions at some later point, the legal issues will be solved.

While there is a lot of knowledge among innovation leaders and performers about blockchain in the Danish industry, it is also very interesting to see that some believe that they will not be affected by blockchain as much. 35 percent of the companies in the knowledge-based services industry believe that blockchain will not at all become a part of their business within the next two years. Among those companies are consulting and accounting firms.

However, in general one can state from the survey that the higher the blockchain-knowledge of a company, the higher the likelihood that it expects that blockchain-based systems will become a part of their business, already within the next 2 years. What is striking here is that even with in-depth knowledge about the pros and cons of blockchain solutions of today, companies with knowledge expect a swift integration of blockchain, compared to their followers.

One should highlight that regarding the perceived innovation climate in Denmark, smaller companies have reported that they see more issues with the innovation climate in contrast to larger companies. This can be interpreted that it seems to be more difficult to innovate with blockchain solutions for startups that are "blockchain born" than for large companies

that use blockchain innovations “as one option among several others”. It is also consistent with the finding that blockchain startups report having problems in getting access to the Danish capital market. However, for a substantiated conclusion one would have to analyze in more detail which aspects of the innovation climate in Denmark are especially hindering smaller companies when it comes to blockchain.

International Comparative Analysis

The comparative analysis considered eleven different countries or entities and their position in the adoption and assimilation of blockchain. Most countries that were observed showed that the leading industries interested in applying blockchain were the financial, insurance, supply chain, trade, and ICT industries. Some countries seem to have a high engagement across all sectors, such as Australia, Canada, China, Singapore, Switzerland and the US. A few countries have particularly shown a great interest in developing a leading position in the blockchain development, such as Australia with their leadership of the ISO standardization group on DLT and blockchain systems, Estonia with its showcase example as leader in public sector digitization.

Countries such as Switzerland or Liechtenstein try to position themselves as “crypto valley” or “crypto country” by creating a positive investment and development environment for blockchain ventures. Examples for their initiatives are the “Swiss Blockchain Federation” or the “Crypto Valley Association”.

Our brief country overview illustrates that there is a clear interest within many of those to develop blockchain solutions through a variety of different initiatives, which could provide some recommendations and motivation for Denmark to do the same.

Scenario Analysis

This analysis took into consideration four different types of scenarios.

As for the “aspirational scenario” about an efficient public-private collaboration, the highlighted opportunities were that it would create new job opportunities along with an entire value creation networks in different industry sectors and Danish labor market. The highlighted risks for this scenario was the lack of qualified experts for these new tasks.

For the “transformational scenario” about having a strong industrial lead, the opportunities showcased for the Danish labor market that it would not only create new job opportunities in the public and private sector, but also improved transparency in all kinds of processes. On the other hand, the risks here could be that the assumed lack of integration of governmental services could also reduce the ability to realize cost savings in comparison to other countries who have already done this.

Continuing, the third scenario focuses on “new equilibrium scenario”, which considers the global competition and dominance perspective. This scenario highlights the opportunities

that could relate to DLT and further investment in legacy technologies, which could attract innovators and establish a strong labor market. As for risks, if the Danish industry would lose business to other countries that are integrating DLT-based platforms, it could have negative consequences for the Danish labor market, as well as potentially lead to “de-skilling” of the national work force, as DLT-skilled workers would travel to countries with DLT-related opportunities.

The last and most grim scenario is the “collapse scenario”, where DLT solutions are only applied in some niches. This scenario showcases the worst-case scenario, where the opportunities would be very little, and the risks would be high. DLT-driven platforms would negatively affect efficiency and led to diminishing revenues and job opportunities.

Overall, these scenarios provide a comprehensive overview of potential outcomes of the adoption of DLT for the Danish labor market and supply chain industry. This insight can be a foundation for future strategies and decisions.

Limitations of the study

Researching the effect of an emerging technology such as blockchain on industry on macroeconomic level comes with some challenges. While the Danish industry as well as blockchain startups are showing all the signs of a prosperous, and blockchain-affine development, it is not exactly an easy task to locate companies within the emerging blockchain industry cluster in Denmark. We found that some internationally well-known and successful ‘Danish’ blockchain companies have their headquarters not legally registered in Denmark, such as Chainalysis or MakerDAO. While this does not diminish their importance as blockchain innovation engines for Denmark, it makes it more difficult to economically assess the blockchain industry cluster, if key players are not registered in Denmark, are taxed abroad, or have many employees located elsewhere.

Likewise, our study did not give full justice to the several blockchain initiatives rolled out within the public sector in Denmark, as our focus was on the private industry. Thus, the economic implications due to the innovative use of blockchain solutions for, e.g., the registration of vehicles in Denmark or the national ship registry is not covered.

To achieve deeper insights into the challenges and opportunities for Danish companies already using or planning to use blockchain, another research needs to follow up on those companies having or planning blockchain projects, as well on the blockchain industry cluster itself. With the current survey format, we were not able to disclose the direct and indirect dependencies as well as any multiplier effects within the blockchain industry cluster, as it was necessary to identify them first, as we did in this study. Another project would be needed to perform a sound cluster analysis to disclose direct, indirect, and catalytic economic effects. So far, we have only illustrated some multiplier effects, e.g., which factors are of critical importance for obtaining a positive commercial outcome.

Recommendations

Based upon the results of this study, it is the belief of Danish industry that blockchain will make major inroad in many companies improving business processes already within the next two years. Given the huge number of different application fields for blockchain and DLT systems in general, the technology is most likely to become part of the Internet as we know it as well as will give rise to a completely new form of Internet allowing for autonomous proactive systems as IoT and automatic vehicles. Thus, blockchain does not only play an important economic role, but also an important societal role.

Together with artificial intelligence, it most likely will give rise to “digitization 2.0”. With the introduction of DLT systems, value transactions without dependence on or trust in third parties became feasible, enabling companies to establish new value streams.

This is why the “internet of values and trust” is often mentioned in this context. DLT systems and blockchain are not “yet-another-technology”, but will affect societal aspects and fields of politics that are typically not affected by digital technologies. Certain promises of blockchain such as certainty, trust, truth, transparency and so on are so fundamental that it is not possible today to fully grasp the lasting potential impact of blockchain on society and industry.

Thus, applying blockchain is not just a matter of getting the typical benefits from a new technology providing better effectiveness or efficiency. We thus recommend for Denmark as well as for individual companies to establish a blockchain strategy.

Impact on Business Models

DLT systems may provide totally new services at all levels of society. That may include, but is not limited to, intelligent cities where blockchains offer new possibilities for sharing services, intelligent transportation services, or smart energy grids. These and many more application areas need to be examined and prototyped.

Blockchains may help improving access to capital markets or will provide banking services for unbanked user groups that may increase market sizes as well as social justice. Not surprisingly, institutions such as the United Nations or the World Wildlife Fund regard blockchain as a humanitarian, or welfare technology. The examples illustrate that blockchain technology may open new opportunity areas that go beyond the traditional business areas. A key learning here is the widespread level of possible activities from using blockchain, many of which are innovative offering services not previously available to society. The opportunities for developing and applying blockchain welfare solutions need to be examined and use-cases prototyped.

One of the promises illustrated by blockchain solutions is “getting rid of the middleman”. For this to be spread out in industry and the opportunities and risks to be illustrated and solutions as use-cases need to be examined and prototyped for stakeholders to get

inspired. The establishing of such environments and practical applications may be financed by public means or private funds.

Another promising application area are the new levels of digital privacy possible through blockchain - and how to enforce them through universal wallets. This example is both related to the next recommendation as well as need to be mapped out and understood by itself.

Actions required by Companies

There is a need for education on all levels, especially at the executive level, to develop the needed blockchain mindset to evaluate business opportunities and challenges around potential blockchain solutions. The need for courses covering technical and economic aspects of the emerging blockchain economy for developers and executives at high level will allow to discover and realize business opportunities.

A blockchain mindset will also sharpen the needed end to end perspective to deal with the complexity of DLT systems. What is needed is blockchain know how that enables executives to make evidence-based decisions to launch new products and services. Executive understanding and insight into the blockchain peculiarities that can be directly translated into benefit is one of the key findings of this report. This is further emphasized by the finding in this report that in the case of blockchain top performers, the digitalization level of the company influences the most the blockchain assimilation with respect to all other subsets: excellent company performances and a high digitalization level are prerequisites of high blockchain assimilation. The need for thorough education of highest quality is a must for envisioning and achieving global leadership in the field. Accompanying funding is required in addition.

With the anticipated level of activities reported by Danish companies and with their focus on the risk for bottleneck issues from too few blockchain knowledgeable system resources, there is a need for developing specific blockchain update courses for system-developers to obtain enough volume for Danish society and industry.

The solid evidence from this report on the need for decision makers in industry to clarify the future positioning and strategy for blockchain development and assimilation in their organizations and their environments with a focus on how each organization and its ecosystem can build upon that strength and steer its blockchain development into the future.

Actions required by Industry and Society

From the scenario analysis it follows that there is a need for having a strong industrial lead to inspire and guide politicians and regulators in their activities.

An application of potentially tremendous importance and global reach could be the development of a Danish based global, universal wallet, as a successor of NEMID or myID.

Such wallets are able to do more than just store cryptocurrencies, as they will proliferate the use of all kinds of tokens which will gain increasing importance in the future to manage the countless “identities” a person or entity has in numerous automated transactions and services a citizen or consumer is involved in.

These global wallets are often regarded as the central application that will enable each of us to control our identities and data in the future. As Denmark has a long history in identity management systems, and with the prospect that universal wallets will become the key to give control back to the citizens over their digital traces, Denmark is well advised to build upon that strength. It should be noted the potential use goes far beyond financial transactions. A global wallet is an application not only for human/system interfacing but also for system/system use. It is thus relevant for all aspects of system contacts in the future. Development and use of such services may provide significant potentials on a national and international scale.

To facilitate entrepreneurship in the blockchain area, the need for non-bureaucratic financing should be emphasized. This is essential for establishing viable start-ups and to a lesser extent for larger companies. In so doing, Denmark has the potential to establish itself as a global player in the emerging blockchain industry, while preventing a drainage of Danish blockchain talents who currently may go abroad to start their business.

Our brief country overview illustrates that there is a clear interest within many countries to develop blockchain solutions through a variety of different initiatives to get a leading position in the blockchain game providing support, economical and legislative which could provide recommendation and motivation for Denmark to do the same.

Even if the companies surveyed in this study do not wait for government initiatives on blockchain, it should be emphasized that some of the deeper societal opportunities from blockchain may only be realized through public initiatives that need to be embedded in a national blockchain strategy for Denmark.

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